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CONTENTS:

	PAGE
Underground Lines	309
Copper Wire	309
The Introduction of the Electric Light in Frankfort-on-the-Main (*concluded*)	312
On the Electrical Resistance of Iron and its Alloys at High Temperatures (*illustrated*)	313
Telephonic Specific Inductive Capacity	314
Communications from Austria-Hungary	314
The Scientific Use of the Phonograph (*illustrated*)	315
Connecting or Disconnecting Electric Circuits (*illustrated*)	317
Lightning Conductors (*continued*) (*illustrated*)	318
The Agricultural Hall Exhibition	321
Review:—Electrical Engineering for Electric Light Artizans and Students	322
Tractive Force of Leather Belts on Pulley Faces	323
Notes	324
City Notes, &c.:—Exeter Electric Light Company	327
Newcastle Electric Supply Company	328
Elmore's Wire Manufacturing Company	328
Traffic Receipts	328
Electric Lighting at the Universal Exhibition of 1889	328
Electricity as Applied to Street Railways	330
New Patents	333
Abstracts of Published Specifications	334
Correspondence:—	
Alternating *v.* Continuous Current Motors	334
Hydro-Carbons in Arc Lamps	335
Lightning Conductors	336
Wynne's Patent Electric System	336
Far Distance Dynamo (*illustrated*)	336
Subdivided Conductors for Electric Traction	336

UNDERGROUND LINES.

THE *Annales Télégraphiques* contains an article by M. Xavier Schaeffer, in which he relates his experiences during repairs to percha-covered underground wires in Maurienne (Savoie). The overhead telegraph lines had to cross many exposed localities, where they were subject to damage from floods and avalanches, and in these situations, as well as in tunnels, it was considered advisable to bury the wires. This was carried into effect in 1885, the overhead lines being joined to the underground portions at small huts fitted with Bertsch lightning protectors.

Since their construction these underground lines have been repeatedly damaged by atmospherical discharges, and their condition became so aggravated that in 1889 it was resolved to thoroughly overhaul the whole system.

The wires are carried in conduits open at the top, so as to allow the former to be laid loosely and without any hauling. A shoulder on each interior side of the conduit permits, after the wires are laid, the chamber to be closed in by means of thin cement slabs. Over these slabs liquid cement is poured, filling up the remaining portion of the conduit.

We gather that the cables, if we may call them so, were manufactured in France. The percha seems to have been covered with a spiral tape, and over all an outer protection of tanned jute was laid.

M. Schaeffer attributes the faults he discovered to the following causes: 14 from lightning, 1 in the manufacture, 4 from blows of picks or crowbars, 1 rat bite, and 10 due to hauling or handling.

At all those places where, according to Mr. Schaeffer, the cables were damaged by lightning, the percha was found to be extremely fragile; it was of a white colour, much cracked, and came away with the slightest rubbing, a very small degree of tension being sufficient to break it. The coverings of tape and jute were completely decomposed and no longer afforded any protection. If an attempt were made to move the cables from the conduit the percha split in all directions, and fresh faults were created.

In many localities the percha was found to be excessively porous and impregnated with a yellow viscid fluid which could be squeezed out of the percha with very slight pressure of the finger. M. Schaeffer considers that the presence of this fluid arises from the decomposition of the outer coverings.

Some of the changes which were found to have taken place in the nature of the percha with a consequent distinction of the insulating material are attributed to the presence of stagnant water in the conduits.

M. Schaeffer imagines that the damage caused by lightning may be due to direct discharges from the overhead wires, the Bertsch lightning protectors being ineffective for the purpose required; he also thinks it possible that the inductive effects of atmospherical discharges in the neighbourhood of the conduits may have had some share in the matter.

COPPER WIRE.

IT scarcely seems credible in these days of electric lighting and transmission of power that less than 20 years ago the use of copper wire in the electrical industries of that period, was practically limited to the winding of coils for telegraphic and measuring instruments and the manufacture of subterranean and submarine cables. The telephone had not sprung into being, dynamos were only in embryo, and undreamt of were the manifold uses to which copper wire is now being put. Nevertheless, what little employment for it existed, the wire was of a nature which demanded the same high conductivity as we seek now, but it was not so readily obtainable and the incorrectness of Matthiessen's standard was only known to or suspected by a few.

Vast changes have been produced in the copper market during the past decade, not the least important

being the fact that this metal has been gradually replacing iron for aerial telegraphs, for reasons which need not be here specified; but this seems as nothing to what we may expect within a like period from the present moment. The method also of producing high conductivity copper wire of nearly absolute purity, appears likewise to be on the verge of undergoing a radical alteration.

Our readers are all aware of the Elmore process of building up copper tubes by electro-deposition and now we have before us the prospectus of a wire manufacturing company which is formed to acquire the exclusive British license to make all kinds of wire, ribbon, tape and rod by the Elmore process.

By the Elmore process, in the one operation of refining the copper from the rough Chili bars, pure copper in a tubular or cylindrical form is automatically produced, and from this the wire is drawn.

Messrs. Clark, Forde and Taylor who have had considerable experience with this electrically deposited copper have reported in most favourable terms upon the character, both electrical and mechanical, of the metal, which is capable of being made both hard and soft as may be required, at the same time retaining its high conducting power. The board of directors of the Elmore Wire Manufacturing Company, which, by the way, appears to be a working body, is satisfied that their wire will become the standard for electrical and general purposes, and they put forward two essential and, as they say, indisputable facts which practically guarantee the success of the company.

1. *The process produces an article of commanding superiority over anything in competition with it.*

2. *The cost of manufacture is far less than that of the best quality of copper wire hitherto produced.*

It seems to us that on the last mentioned clause the company's chances of success must almost entirely depend, as we are inclined to think that the "commanding superiority" of the Elmore copper as an electrical commodity is more apparent than real, for we have recently tested some wire having a conductivity of over 100 per cent. according to Matthiessen's standard, with which Elmore's metal was compared by Messrs. Clark, Forde and Taylor. It remains for other manufacturers to show to what extent the cost of electrolytically formed copper is below other methods, but we must say that the prospectus is worded in a very confident manner, and as if the directors were quite sure of their ground. If their anticipations are verified the outlook is certainly favourable both to the electrical industries and to the investing public, but we cannot forget that we may expect improvements in the smelting and refining methods and also that anyone is at liberty to produce copper by electro-deposition. Therefore it seems scarcely probable that the company will enjoy that monoply of the wire industry which the Board appears to anticipate.

From this point of view, the price asked for the license, *viz.*, £75,000, and half the amount of premiums received by *any* issue of shares and amounting by the present issue *only* to, say, £50,000 with 10 founders' shares of £2, *i.e.*, £125,020, may seem to many very high, so high, indeed, that we think the possible payment of half the premiums on further issues of capital seems hardly worth much consideration.

Dynamo Designing.

THREE weeks ago we made the observation that the men who design dynamos have points to consider which are not discussed in text books or referred to in professorial lectures. Amongst these we instanced as one point the ampère turns which can be carried by armatures without causing sparking, as another the excitation required in actual dynamos to compensate the weakening effect of the armature current. Prof. S. P. Thompson, in his letter of last week, characterised our remarks as hardly just, but we venture to think that our esteemed correspondent may have taken them in a sense somewhat more comprehensive than was intended. It was not said that "such points as come into the practical designing of dynamos are not referred to in professorial lectures," for we believe that the professors deal with all the practical points of which they possess a knowledge. But that there are many points to be considered in designing not referred to in lectures must be obvious, and probably Prof. Thompson himself would be the first to admit it.

Armature Loads.

THAT the points referred to have received hardly any attention is evident from the three nights' discussion we have had. As regards the armature load, the rules employed by the several designers are not in agreement, though one result from the papers may be the adoption of some sort of general expression for the permissible number of ampère turns. But until the papers of Messrs. Swinburne and Esson were read, not a sentence had been published, so far as we are aware, on the subject. As regards the demagnetising effect of the armature current, it is well known that this depends on the lead of the brushes; but in Swinburne's paper is given the first attempt to determine the lead before the machine is built. With all deference to Prof. Thompson, we may say that the consideration of these questions commenced only with the two papers referred to, and while statements to the effect that overloading is bad, have been plentiful enough, only now do we find attempts made to connect naturally the load with the dimensions of the machine, and to determine, in designing, the lead of the brushes.

Arc Lamps.

THE interesting letter sent to us by Mr. Grout bears out all our contentions of last week on the subject of introducing hydro-carbon vapours into the electric arc. The old patent of Messrs. Grout and Sennett shows clearly that so long as ten years ago, all the experiments recently made on behalf of the inventor of the lamp to which we referred, were fully threshed out. For the benefit of those who appear to be interested in reviving and booming an abandoned idea, the number of the specification is 2,267, of December 22nd, 1879.

Telephonic Specific Inductive Capacity.

ON another page we publish the results of some experiments of considerable scientific and technical interest recently made by two students of the Massachusetts Institute of Technology, and which were recently presented by Mr. W. W. Jacques to the American Academy of Arts and Sciences.

Electric Light in Warfare.

EXPERIMENTS have been recently carried out at Toulon with the view of determining to what extent accuracy of aim could be attained at night with the use of the electric light. A 19 cm. gun was mounted on a revolving platform which also carried an electric projector. The targets were fixed at a distance of between three and four kilometres, and it was found that the same accuracy could be attained under these conditions as during daylight.

Theory and Practice

The man whose work lies in practical channels relieves his feelings occasionally by railing at the theorist, the probability being that at one time or another he has suffered at his hands. But if theory presents a consistent aggregation of the general principles upon which practice ought to proceed, why should theory and practice be generally regarded as in a measure antagonistic? The reason, we fear is, that theory has seldom or never borne out its pretensions, and this is particularly true as regards the designing of heavy electrical machinery. Ten years ago the theory was considered to be in advance of the practice, if we might so put it; little or nothing was known of the scientific principles underlying the construction of dynamos, and engineers were only too pleased to impress the physicists in their service. Every suggestion was acted upon eagerly, every hint taken thankfully. If they were told to make long, thin magnets, they made them, though of course they were no improvement. If they were advised to pile the bulk of the exciting wire on the middle of the magnets, straightway they piled it there, but got nothing for their pains. If later they were told to adopt large armatures and small fields for their motors, they took the advice, but the arrangement failed to work. The assumptions upon which the various theories dictating these notions were based, were unfortunately untrue. The dynamo differed from every piece of electrical apparatus which had existed before, and the various suggestions from previous experience were found of little benefit. Engineers, when the machine became an article of commerce decided to trust to their own experience rather than be guided longer by the physicist and his theories.

From the Laboratory to the Workshop.

THE theorist had undoubtedly done his best. He had culled from the experience of the past the facts he thought useful, and had indicated to the best of his ability their application. He could do no more, for he had neither the opportunity nor the means to test his theory by constructing machines. His theories were wrong, that is all. He had started on false premises, and the general principles derived therefrom were in consequence inapplicable. When the machines were built they did not fulfil expectations, but having them to experiment with, the constructor could determine how to improve them without the physicist's aid, and so, slowly but surely, engineers are building up for themselves a true theory of the dynamo.

Experiment must be on a Practical Scale.

SO long as he can construct in his laboratory apparatus comparable in size with that to which the laws he formulates are to be applied, the pure theorist gets on well enough. If with bits of sealing wax, knitting needles and string he can imitate the practical appliance and approximate the conditions under which it works, he can doubtless give us very valuable information. But with heavy electrical work this cannot be done. Experiments on a laboratory scale teach us little, and the equipment of laboratories on a practical scale seems at present beyond the means of our technical institutions.

£10,000 Wanted for a Research Laboratory.

THE electrical Professor, truth to tell, occupies at the moment a somewhat sorry position. He has no opportunities for original research because the cash is not forthcoming. He has to peddle along with two or three antiquated machines, or perhaps with only one, bought second-hand at a sale. His knowledge of modern appliances he has to pick up from the makers, who are not always very ready to give the information. His teaching may be excellent, but there is nothing new of practical value produced in his laboratory. He is degraded to the position of a mere instructor, when he ought to be directing a large research staff, and his College ought to be the centre of electrical progress. We want a research laboratory badly. It need not have a fine red brick front or a graceful colonnade, but it should be furnished with the largest sizes of dynamos and engines, in regular use and devoted exclusively to electrical research. The machines would be bought or borrowed, as the case might be, and altered or modified according to the object in view. The work would be directed by some electrical engineer of eminence, whose movements would in turn be guided by a board of management, consisting of practical engineers elected by the subscribers. But that last word arrests our flight and brings us to earth again. Where is the £10,000 to come from?

Electricity and Gas.

HOWEVER regrettable the fatal accidents caused by the electric current may be, there is scarcely sufficient justification for the panic which the supporters of gas lighting are endeavouring to propagate in the United States. In the year 1889 there were some fatalities caused by electricity in America, while during the same period there were 109 persons whose deaths were directly attributable to gas, with, in the majority of cases, the accompaniment of prolonged and severe suffering, a condition which is, at all events, absent from death by electricity.

Electrical Distribution.

WHAT is wrong with the Sardinia Street central station? If report speaks correctly, serious troubles have already been experienced, but we trust that they have not set in for a permanency. We would recommend those in charge to read, learn, and inwardly digest the series of papers just commenced in *Industries* from the pen of Mr. James Swinburne, and entitled "Safety in Electrical Distribution." It is the intention of this gentleman to show that, with reasonable precautions, it is possible to render the electric light, not absolutely infallible, but, as the writer quaintly terms it, "almost perfectly safe." We venture to think that what Mr. Swinburne deems reasonable, many others may view in an entirely different light, and in his very first essay there are several passages to which we may shortly turn for the purpose of endeavouring to show how utterly unreasonable his reasoning seems to be. He is too prone to employ autocratic utterances, and he does not allow for differences in mankind.

THE INTRODUCTION OF THE ELECTRIC LIGHT IN FRANKFORT-ON-THE-MAIN.

[FROM A CORRESPONDENT.]

(*Concluded from page* 281.)

Question X.—To what further remarks do the various documents and projects and the observations made during the experiments give rise?

Those incidental questions not mentioned in the schedule, but to which the study of the documents and proposals and the measurements and experiments undertaken gave rise have, with one exception, been discussed in dealing with the main questions. A further question of great importance was examined in testing the projects, and especially in negotiations the proposals in the presence of the delegates. It relates to the working of tramways by electricity.

A discussion of the question in which tramways might best be worked electrically led to the following views :—

A direct propulsion of tramcars by electric motors introduced into the cars and deriving their current immediately from the central station by means of aboveground leads is impracticable in Frankfort. If a direct propulsion is chosen the current of the motors would be most conveniently conveyed by underground leads laid in grooves beneath the rails. Such an installation is naturally exposed to various accidents ; dirt, violent falls of rain and snow, and mischief may cause earth connections and short-circuits which, if the leads for motive power are in connection with those supplying light, may interfere with the latter. Besides the considerable fluctuations in the consumption of current, which would occur at certain times in working trams, would have an unfavourable effect on the supply of light in the part of the net affected. The greatest activity of the tram-lines falls in the evenings of the days before Christmas, and coincides, therefore, with the greatest demand for light, whilst just at this season interference by snowstorms are most to be expected. But if the greatest activity of the tram-lines coincides with the greatest demand for light, a direct electric propulsion of tram-cars by means of the general net of leads from the central station admits of no more rational utilisation of the cables, which, in any case, are required for the sake of light. The cables would therefore have to be selected of greater strength than would be requisite for lighting purposes.

Their joint arrangement, therefore, is necessary neither on financial nor on practical grounds. Whether alternating or continuous currents are selected for working the central station, it would be preferable to lay down independent leads, if a direct propulsion of the cars were agreed on.

It would, however, be desirable, if not absolutely necessary, to keep the motive power leads for working the tram-lines as equal as possible to the illuminating leads, both in the kind of current and in the height of its tension ; so that in case of disturbance in any part of the tram-line which cut it off from the central station, such portions might be temporarily supplied with current from the lighting net.

In the proposed "five-lead system," the tension at the central station would be at once suitable for the demands of the electric tram-lines. The conductors could therefore at once ramify off from the collecting table.

In the continuous current transformer system the working net of the tram-lines would receive the current from the transformers of the secondary stations or from special transformers placed at suitable points along the tram-lines, and with the tension of the light conductors, *i.e.*, 220 volts.

In the alternating current transformer system, if it were thought preferable to use continuous current motors for the tram-cars, the lead would at once be taken from the machines at the central station, which for the purpose would be arranged with a corresponding tension. If the tram-line is worked with alternating current motors their working leads can be simply fed from the primary leads by means of transformers.

But if the development of accumulators for driving carriages has in the mean time so far advanced that they afford the most rational and certain solution of the tram-line difficulty, the charging of the accumulators could be directly effected on the continuous current system from the general lead. If the alternating current is employed, it may be effected by utilising of the exciting machines of the central station, and by laying down special leads for charging.

Hence, as regards the question of the electric working of trams, it appears to us quite indifferent which system of currents is adopted. We see no grounds for transfering the present decision on the system of current for lighting by appending to it the propulsion of tram-cars.

Questions XI and XII.—The System for Frankfort.

What is the respective position of the various systems proposed as regards expense, simplicity, trustworthiness, safety and success ? Which system appears finally the most suitable and most to be recommended for the entire supply of Frankfort, regard being had to the existing circumstances and to local conditions and demands for light and power ?

To these questions the Commission cannot give in common a definite and complete answer, because :

1. The project of the firm of Schuckert and Co., depends upon the introduction of accumulators on the large scale, as to the performance, trustworthiness, and especially on the durability of which the views of the Commission are not in agreement.

2. Accurate calculations, drawn up on a similar basis, for deciding the financial phase of the question, both as regards the installation in its original extent and in its ultimate extension, and in the various stages of its development, are wanting.

3. The project of Schuckert & Co. is not furnished with a plan of the conductive net.

4. The five-lead system of Siemens and Halske with reference to the position of the central station (according to the accompanying appendix by the Mayor-in-Chief, Dr. Miquel, Appendix III.), does not seem to us to admit of discussion.

5. The decision on the financial aspect of the projects depends essentially on the question whether the suggested installation of turbines at the "Nadel wehr" will be built in connection with the electrical works, and whether they will be partially, or not at all, debited with the expense of the turbines.

For a definite reply to these two questions a closer knowledge of local relations is needed than the majority of the Commission can lay claim to.

If, however, the Municipality wishes a complete and accurate comparative decision on the proposed systems, a reply to the question as to the installation of turbines at the "Nadel wehr" would be necessary, as well as a complete and equable investigation of the estimates for installation and working.

(Signed)

GALILEO FERRARIS,
Professor at Turin,

W. H. LINDLEY,
Municipal Architect at Frankfort.

DR. KITTLER,
Privy Aulic Councillor, Professor of the Technical High School of Darmstadt.

F. UPPENBORN,
Director of the Electrotechn. Experimental Station at Munich.

Dr. H. F. WEBER,
Professor at the Zurich Polytechnicum.

Paris Lighting.—The sum set aside by the Paris Municipality for the lighting of the city during 1890 amounts to 782,750 francs, of which 100,000 francs will be devoted to experimental lighting.

ON THE ELECTRICAL RESISTANCE OF IRON AND ITS ALLOYS AT HIGH TEMPERATURES.

AT high temperatures malleable iron undergoes two molecular reversible transformations, which are characterised by more or less considerable absorptions of heat (M. H. Le Chatelier, *Comptes Rendus*). These transformations were discovered by M. Osmond, who at the time pointed out the importance of the part which they played in the metallurgy of iron. The first, which is only slightly marked, is generated at 730°, that is to say a temperature bordering upon that of the recalescence of steel (700°); the second, which is accompanied by a greater absorption of heat, is produced at 855°.

When dealing with carburetted steel, M. Osmond noticed that the transformation became less marked in importance and lower in temperature proportionally as the carbon increased in amount, until, in the case of hard steel, the transformation became absorbed in the recalescence. It is true, as M. Osmond pointed out, that the method of experiment employed left room for a certain amount of uncertainty as regards this. The reduction and diminution referred to were possibly only apparent and were the results merely of a kind of partial and transient tempering occasioned by the very rapidity of the cooling process.

It would be interesting to elucidate this question if only for the connection it has with the tempering, properly so called, of steel. Tempering by water has, according to M. Osmond, the effect of maintaining at the ordinary temperature the varieties of iron and of carburetted iron, which, normally, are stationary at over 860° and 700°. Tempering by means of lead would merely maintain the variety of iron in its condition of unstability, and would be no hindrance to the normal transformation of the carburetted iron in the cooling process.

In order to obviate the difficulty, we must have recourse to those properties of iron which vary with the temperature, but whose measurement it is possible to take at a stationary temperature, when sufficient time has elapsed to allow of the metal acquiring its condition of fixed equilibrium.

Measurements of expansion taken for this purpose lead to no precise result; the abrupt variations in length which formed the subject of observation, were of a degree analogous, as regards magnitude, to that of experimental errors. I then undertook the study of electric resistances, and the results of my experiments are shown in the following tables and figures, and are supplemented by others having reference to nickel and platinum. Resistances are expressed in ohms and have reference to wires of 1 m. in length and 1 mm. in diameter. All the experiments, except those with platinum, were made in pure and dry hydrogen.

Very pure malleable iron: C = 0·05 per 100.
Scoria inserted about 1 per 100.

t	...	... 15°	290	460	750	800	860	910	1060
r	...	0·14	0·38	0·59	1·10	1·21	1·31	1·34	1·40

Fused steel: C = 0·6 per 100.
M_a = 0·4 per 100.

t	...	... 15°	300	420	600	700	820	960	1100
r	...	0·16	0·43	0·55	0·80	0·97	1·28	1·32	1·34

Hard Steel.

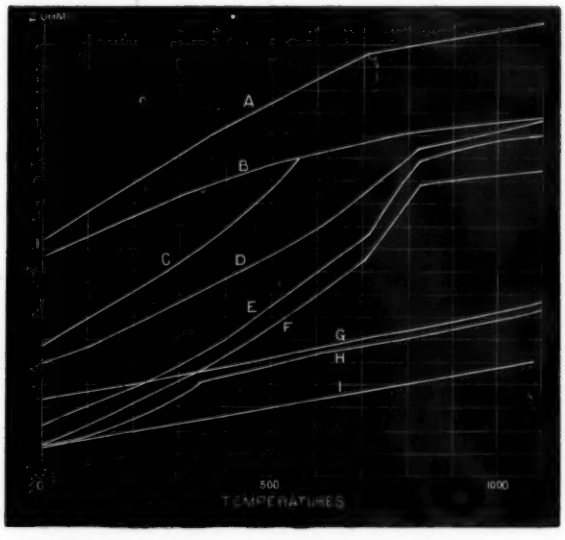
t	...	15°	280	410	680	730	830	870	940	1050
r	...	0·24	0·46	0·60	1·06	1·13	1·39	1·43	1·46	1·48.

The curves in relation to the iron and to the steels, properly so called, indicate very clearly, by the angular points developed by them, the two molecular transformations, and, moreover, make it apparent that the temperatures of these transformations are independent of the proportion of extraneous ferrugeneous substances.

Manganese steel with 13 per cent. of mn., which is not really a steel but an alloy of iron and manganese, presented a rather doubtful angular point at about 700°. I propose to return to them when investigating the action of the tempering that produced such curious effects upon this metal.

Nickel furnished a very well-defined angular point at about 340°.

Platinum and rhodium-platinum, which were employed in the construction of my thermo-electric couples, presented a resistance which increased proportionally with the temperature.



A, Manganese steel with 13 per cent. manganese.
B, Ferronickel with 25 per cent. nickel.
C, Ferronickel modified.
D, Steel with 3 per cent. silicon.
E, Hard steel.
F, Steel, semi-hard.
G, Platinum with 10 per cent rhodium.
H, Nickel.
I, Pure platinum.

Ferronickel with 25 per cent. of nickel, furnished some very interesting phenomena. Heated in pure and dry hydrogen it underwent no alteration, and its curve of resistance remained perfectly regular without presenting any angular point; on the other hand, when heated in damp hydrogen it underwent an important modification. Its colour, from yellowish grey became steel grey, whilst its mechanical properties underwent the following transformations: The tenacity rose from 65 kg. to 80 kg.; the extent of the break from 65 per cent., fell to close upon *nil*; and lastly, the elastic strain limit became more than doubled. The electric resistance was then diminished by one-third. The resistance curve of the new metal gave, when heated, an angular point at 550°; and, moreover, was superposed to the normal ferronickel curve. In the cooling process the two curves remained superposed up to about 100°; but thereafter the resistance diminished progressively to rejoin the curve of modified metal. There was, therefore, during the cooling a delay in the transformation analogous to that produced by the tempering in the case of the steels, but it was impossible to avoid this even with very slow cooling. This change wrought in the ferronickel by the damp hydrogen appeared to be due to the oxidation of the silicium, an element which enters to a slight extent into the composition of this alloy.

Since completing the above experiments I have become aware of a similar investigation by Dr. Hopkinson, which has been published in the *Philosophical Transactions of the Royal Society* for 1889, but not yet been circulated. His experiments had reference to malleable iron, semi-hard steel and manganese steel. He found, at 855° and 815°, the points of transformation of iron which were obtained by me at 850° and 820°. But he failed to detect the point of transformation at 710°, either in the hard or in the manganese steel.

TELEPHONIC SPECIFIC INDUCTIVE CAPACITY.*

By F. H. SAFFORD and G. U. G. HOLMAN.

IN a paper on the "Construction of Telephone Circuits," read before this Academy on June 15th, 1887, by the Electrician of the American Bell Telephone Company, Dr. Jacques, it was pointed out "that the readiness with which telephonic conversation may be carried on over any circuit, whether made up of cables or pole lines, or both, depends :—

"1. On the total electrical resistance of the circuit joining together the two stations.

"2. On the total electrostatic capacity of this circuit."

And the general rule was laid down :—

"No matter what may be the distance between two points, good business conversation may be carried on between them, provided they be connected by a pole line or cable, or both, the product of whose total resistance by its total capacity is less than 2,000, if transmitters of the Blake type be used, and less than 4,500 if transmitters of the Hunnings type be used."

It is evident, therefore, that in the construction of a telephone line it is desirable to reduce both the *resistance* and the *capacity* to a minimum.

In a pole line, since the wire is suspended high above the earth, the capacity is always small, and the resistance is the factor that we must try to keep down.

In cable lines, however, where the conductor is necessarily brought near to other conductors, or a metal shield, or the earth, the capacity becomes quite an important factor to be respected.

In lines made up, as is most generally the case, of a comparatively short section of cable and a larger section of iron pole wire, the capacity of the cable becomes pre-eminently the factor to be respected, for, since the limit of conversation is here determined by the product of the capacity of the cable and the resistance of the whole line, a small percentage of saving in the capacity of the cable gives an enormous gain in the readiness with which conversation may be carried on over the line.

It becomes of vital importance, therefore, to choose an insulating material for telephone cables of low specific inductive capacity.

We have accordingly measured the electrostatic capacity of a considerable number of substances used for insulating wires in cables, and, since the specific inductive capacity for the same insulator is very different for telephone currents from what it is for telegraph currents, because the charge and discharge take place so much more frequently, we have adopted a method and apparatus in which currents of telephonic frequency are used.

This apparatus is a Gordon induction balance (see Gordon's "Electricity and Magnetism," p. 110), in which the substances were charged and discharged by currents from an induction coil, and the balance was observed with a telephone instead of an electrometer.

With this apparatus we measured the specific inductive capacity of a considerable number of insulating materials, and each when subjected to various rates of charge.

We found that the capacity varied very materially with the rate of charge, some substances increasing and others decreasing, but no general rule was evolved.

We found that measurements of the capacities of telephone cables made by the ordinary galvanometric measurements gave no indications of the comparative merits of these cables for telephonic work.

Finally, we made an accurate series of measurements of the specific inductive capacity of the following substances, when submitted to actual telephone currents. The values might, perhaps, be called the "telephonic specific inductive capacity," leaving the expression "telegraphic specific inductive capacity" to indicate values measured in the old-fashioned way.

* Read at the American Academy of Arts and Sciences.

Table of Specific Inductive Capacities, measured by Telephone Currents.

Petroleum (Brooks Cable)	1·6
Solid paraffine	2·0
Cotton saturated with paraffine in vacuum (Faraday Cable)	2·0
Cotton boiled in paraffine (Patterson Cable)... ...	2·6
India-rubber	3·7
Artificial gutta-percha (Gwynn)	3·9
Gutta-percha	4·2
Glass	4·6
Water	6·3

An inspection of this table shows that, so far as capacity is concerned, petroleum is the best substance to be used, and doubtless this would be the case were it possible to keep it free from water; but water, we see from the table, has a specific inductive capacity of 6·3, so that its presence in the petroleum raises the capacity from the lowest to the highest in the list.

This observation is borne out by actual experience with "Brooks" cables in telephony. When new, and the petroleum dry, it works excellently; but, as water finds its way in, the cable rapidly loses its efficiency for telephonic work.

This action of the water is quite different from its action as a *conductor* to produce leakage, for the loss of electricity due to leakage in a Brooks cable that has lost its efficiency from the presence of moisture is entirely insufficient to account for the deterioration.

Next to petroleum, solid paraffine is seen to be the best substance to use; but on account of mechanical difficulties it has never been found practicable to coat wires directly with solid paraffine.

If the wires are wound with cotton and then boiled in paraffine, as they are in making "Patterson" cables, the specific inductive capacity is raised to 2·6, an increase of 30 per cent., which we have seen is a very great detriment.

If, however, the wires are wound with cotton, and the air and moisture removed by the aid of heat and a vacuum, and they are then boiled in paraffine, from which the air and moisture have also been removed by heat and vacuum, the specific inductive capacity again falls to 2·0, which is the same as that of solid paraffine. This is the process used in preparing the "Faraday" cable.

It is possible that the inferiority of the Patterson cable, as compared with the Faraday, is due largely to the moisture retained in the cotton, which we have seen has a capacity of 6·3.

Leaving the paraffine cables, rubber is the next best, then gutta-percha, and poorest of all is glass; but all of these substances have so high a specific inductive capacity as to entirely unfit them for telephonic work.

COMMUNICATIONS FROM AUSTRIA-HUNGARY.

(FROM A CORRESPONDENT.)

THE telephonic intercourse between Budapest and Vienna has hitherto been limited to the two central stations, so that parties wishing to speak to each other, after having been called up by the attendant, had to appear personally at the respective telephone offices. It has since been extended to the city nets both of Budapest and Vienna, so that direct intercourse is possible for the subscribers of each. For more than a week all the Budapest and Vienna newspapers are thus in direct communication with each other, and receive reports by telephone instead of by telegraph, as before.

Shortly before the completion of this direct connection between the two capitals of the Austria-Hungarian monarchy the telephone line Budapest-Vienna was experimentally connected with that from Vienna to Prague, and a few Budapest newspaper editors were placed in direct connection with their Prague

contemporaries. The experiments succeeded excellently, and there is a prospect that subscribers in Budapest and Prague can be placed in direct communication with each other at a distance of 680 kilometres.

In the electric lighting of trains practical results have been attained in Austria-Hungary. At present the Austrian north-western line is experimenting with the electric light in passenger carriages. As the source of the current there are employed the accumulators of Dr. Schoop (so-called "dry accumulators"). The Board of the Royal Hungarian State Lines purposes to introduce the electric light in their trains, and is fitting up a train of eight carriages for this purpose. Accumulators of various systems are to be tried.

The representatives of a syndicate which has bought up a large share in the Vienna New Tram Company, and which is in connection with the Berlin General Electrical Company *(Allgemeine Elektricitats Gessellschaft)*, has requested that electric working should be introduced on the main line (Modling-Döbling) of the New Vienna Tram Company. There was laid before the board, a proposal from the Berlin General Electric Company, to the effect that on the line in question electric propulsion should be introduced at the expense and at the risk of the Berlin Electrical Company, and under such conditions that the New Vienna Tram Company would effect a yearly economy of 25,000 florins as compared with its previous expenditure, and further, after fifteen years would become the proprietor of the installation. The board of management, however, seems at present inclined to decline this proposal, as no sufficient guarantee has been offered against injury to the company from possible irregularity in the traffic. The Tram Company is responsible to the Municipality for the regular, uninterrupted service of the line, and the electric working of a tramline which traverses a very populous town has, in the opinion of the board, hitherto not been sufficiently proved. In the event of irregularities, or of the failure of the project, injury would accrue to the Tram Company against which substantial guarantees must be required.

It may ultimately become necessary for the entire electrical installation to be removed, and for the former arrangements to be re-established. For such a case, which would involve a serious loss of capital, the New Vienna Tram Company must be secured by satisfactory guarantees which, as already said, are not offered in proposals for electric working. Without such guarantees the board of the tram company does not feel free to enter upon the experiment of electric working, the more as the company, in the course of last year, in consequence of a strike among the drivers and conductors, had to stop working during the holidays, and had to pay very heavy penalties to the municipality. Having just passed through such a crisis the company cannot expose itself to fresh dangers.

In Budapest the electric working on the tram lines makes constant progress. The management of the electric city line obtains one concession after another, and will shortly possess an imposing net of lines.

THE SCIENTIFIC USE OF THE PHONOGRAPH.*

By GEO. M. HOPKINS.

I.—The Character of the Phonographic Record Interpreted by Vibrating Flames.

THE phonograph in its perfected state, although a scientific triumph and a model of mechanical and electrical skill, is designed for commercial and social purposes rather than purely scientific use. Still it has within itself all the elements necessary for several very interesting physical experiments. These are obviously related to sound or vibratory action, some of them being illustrative of the phenomena of the phonograph itself.

* *Scientific American.*

Mr. Edison in the multitude of his cares finds no time to develop the purely scientific applications of this most interesting invention. He has, therefore, delegated this pleasant task to the writer, who has given the subject considerable attention, and has devised a series of phonographic experiments, one of which is shown in the annexed engravings. This is given first, as it seems best calculated to illustrate and explain the action of the phonograph.

The instrument shown contains all the recent improvements. The phonographic record is made on a hollow cylinder of wax-like material. This cylinder is fitted to a cone mounted on the screw shaft. This shaft turns on two pointed bearings, one of which is fixed, the other being supported by a swinging arm, seen at the right hand end of the machine in the engraving. This construction permits of placing the record cylinders on the cone and removing them quickly and without the necessity of making any adjustments. The screw shaft is provided with a loose central bearing, which holds it up when the end bearing is swung around.

On a fixed rod arranged parallel with and behind the screw shaft is placed a sleeve which carries at one end a spring arm provided with a segment of a nut, which rests upon the threaded portion of the screw shaft. To the other end of the sleeve is attached a curved arm, which reaches over the record cylinder and supports the diaphragm cell. The latter is fitted to a socket in the arm, and is arranged so that it can be turned in its own plane through a few degrees to bring the recording and reproducing styluses into the position of use. An arm projecting from one side of the diaphragm cell is used to effect this change of position, and an adjusting screw, located above the arm, is used for securing a fine adjustment of the reproducing stylus. The enlarged sectional view, fig. 2, shows the diaphragm cell and parts connected therewith, actual size.

The diaphragm is a glass disc about 1·200 inch in thickness. This is clamped at the edge between two thin soft rubber rings. To the centre of the diaphragm is connected a stud, to which is pivoted one end of the lever, *a*. The opposite end of the lever is forked. One arm of the fork carries the reproducing stylus, *b*, and the other carries the recording stylus, *c*. These styluses are made of sapphire, a material which ranks next to the diamond in the scale of hardness. The reproducing stylus is a microscopic sphere or knob, perfectly smooth and highly polished. The recording stylus is cup-shaped upon the end which cuts the record cylinder, and is provided with a very keen edge.

The lever, *a*, is pivoted at or near its centre in a stud projecting from the weighted lever, *d*, which is delicately hinged to the upper part of the diaphragm cell, its lower end being free to move within certain limits. This construction permits the recording and reproducing styluses to follow the surface of the cylinder whether it is perfectly true or not. It also allows the recording and reproducing apparatus to adapt itself automatically to cylinders of different diameter.

It will be seen that the lever, *a*, is one of the first order, with a movable fulcrum, and that whenever the free end of the lever is moved upward by the projections of the record cylinder, it tends to lift the weighted lever, *d*; but owing to the inertia of the weighted lever it is unable to follow all the movements of the lever, *a*. As a consequence the motions of the latter in the reproduction of speech are imparted to the diaphragm. In making a record, the reverse of this occurs, *i.e.*, the rapid motions of the diaphragm are imparted to the reproducing stylus, which cuts in the record cylinder a groove with depressions and elevations which taken together correspond in form to the sinusoidal curve which would represent the sound waves by which the vibratory movements of the recording mechanism were produced.

The arm carrying the diaphragm cell also supports an adjustable turning tool of sapphire, which is arranged to turn off the cylinder simultaneously with the production of the record. This tool is arranged to

automatically disengage itself from the cylinder when the reproducing apparatus is thrown in place.

The phonograph cylinder is rotated by a very perfect electric motor, regulated by a sensitive governor. To the perfect regularity of the motion of this motor much of the success of the phonograph is due, especially in the reproduction of music, where the slightest acceleration or retardation would reveal itself in changes of both pitch and time.

tubes terminating in a slender nozzle, the other being connected with a gas supply by a flexible rubber tube. The perforated cork is inserted in the opening of the mouthpiece, so that gas may flow into the diaphragm cell, and out through the small nozzle, at the point of which it is ignited, forming a long narrow flame. In front of the nozzle is arranged a screen of sufficient height and width to hide the flame.

The other attachment consists of a prism carrying

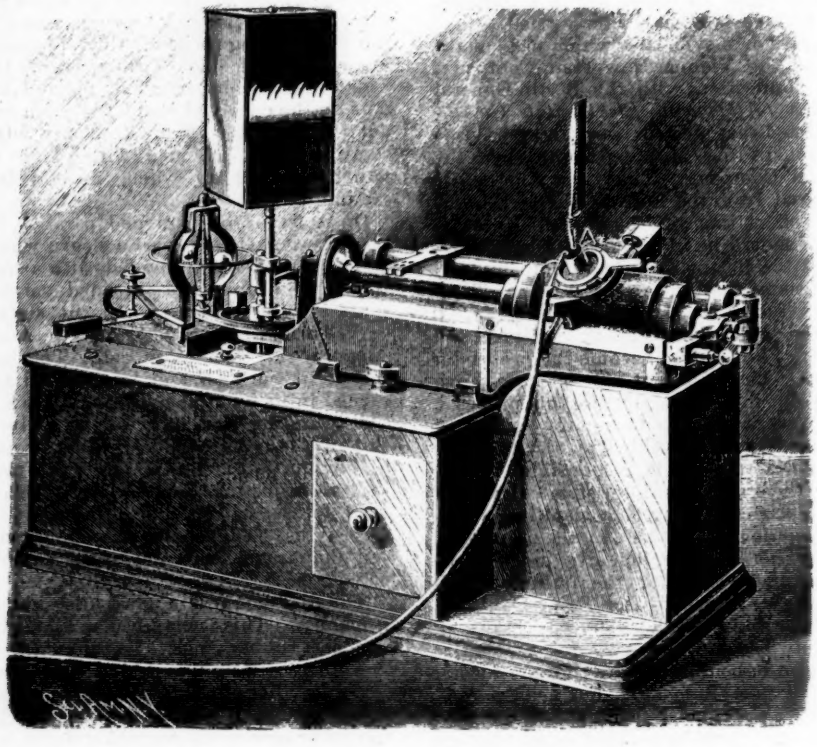


FIG. 1.—PHONOGRAPH—LATEST FORM, WITH VIBRATING FLAME ATTACHMENT.

By applying to the phonograph two very simple attachments, the vibrating flames of Koenig may be produced by the movements of the diaphragm, so that

FIG. 2.—SECTION OF THE DIAPHRAGM CELL.

the character of the phonographic record may be readily understood. One of these attachments consists of two glass tubes inserted in a perforated cork, one of the

on each of its four sides a plane mirror and mounted on a spindle having upon its lower end a friction wheel, which is revolved by contact with the boss of the pulley on the main shaft of the electric motor. The spindle of the mirror is journaled in a sleeve supported by an arm connected with the pointed rod forming the upper bearing of the motor shaft.

Arranged in this manner the mirror revolves whenever the phonograph is operated. So long as the diaphragm of the phonograph remains quiescent the slender flame is undisturbed, and the revolving mirror reflects only a plain band of light; but when the diaphragm is vibrated by the contact of the reproducing stylus with the face of the record cylinder, every projection of the record pushes the diaphragm outwardly, thus forcing the gas outward, accelerating its flow through the nozzle, thereby elongating the flame, while every depression of the record allows the diaphragm to move inward by its own elasticity, thus drawing the gas inwardly, effecting a retardation of the flow of gas through the nozzle, thus causing a sinking of the flame. These changes in the length of the flame take place with such rapidity that no change in the character of the flame is observable with the unaided eye, unless the eyes are quickly turned from side to side, when the vibratory nature of the flame will appear; but no satisfactory analysis of the flames can be made in this way. They must be viewed in the revolving mirror to determine their true form and the relation of the crests and hollows of the flame waves. These flames represent,

in a greatly exaggerated form, the shape of the projections and depressions of the phonographic record. Every vowel produces a characteristic series of waves or flames, the images of which are spread out by reflection from the revolving mirror. Musical sounds from different instruments yield flames differing from those formed by vocal sounds. A song produces a rapid succession of flame images, which constantly vary in form and size.

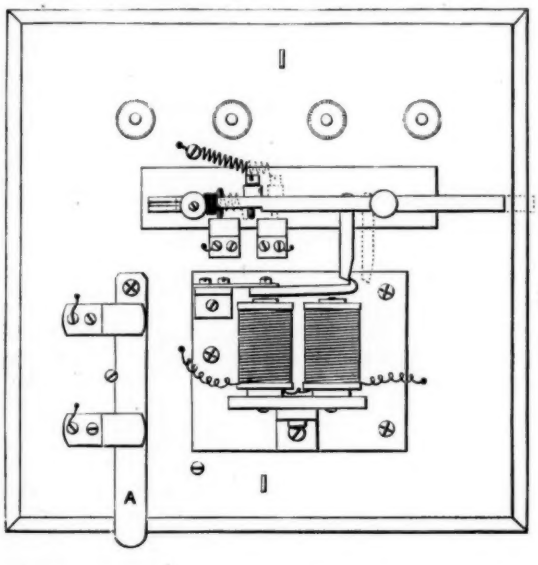
As an aid to the understanding of the phonographic record and the action of the phonograph, nothing can excel this simple device.

CONNECTING OR DISCONNECTING ELECTRIC CIRCUITS.

THE object of this arrangement, the invention of Mr. S. B. McClellan, is to obtain a more simple and efficient means for connecting and disconnecting electric circuits than has hitherto been devised.

The invention consists of a rod mounted in bearings, so as to be capable of sliding longitudinally when required. A spring fixed to this rod gives it a tendency to advance in one direction longitudinally. On this rod screw or other contact pieces are provided, which connect or disconnect electric circuits on the movement of the rod.

In applying the invention to a burglar or other alarm, the inventor places the rod carrying the contact pieces parallel to an armature, on which is a projection ; there



is also a projecting arm or catch on the rod, which comes against, and is held by, the projection on the armature, when the spring on the rod is compressed. On the armature being withdrawn (by, for example, connecting or making the circuit through the opening of a door, or by the burning of a fire fuse), the projection on the armature comes away from the catch on the rod, so allowing the rod to move longitudinally by means of its spring, and thereby to connect the circuit to a bell or bells, which latter ring until the rod is pushed back to its normal position.

The particular point claimed by Mr. McClellan in the invention is that any number of circuits which may require to be connected or disconnected at one and the same time, can be arranged on the bar with great facility, and the rod may be lengthened or shortened to suit the number of contacts required to be made or disconnected. The fig. shows the arrangement, which is self-explanatory, A being only a switch lever for putting the apparatus in or out of circuit.

RESEARCHES ON THE THERMO-ELECTRIC FORCES AT THE SURFACE OF CONTACT OF A METAL AND A FUSED SALT.

THE fact that so many scientists are devoting their attention to the study of the forces developed at the surface of contact of metals and metallic salts is an indication of the importance which is at present attached to this branch of electrical research. The phenomena appear to form a peculiarly interesting study, and doubtless the results which are being so assiduously accumulated will soon provide sufficient material for some important generalisations.

Amongst the most recent contributions to our knowledge of this subject is a paper by M. Lucien Poincaré, which was presented in the form of a Note by that distinguished physicist, M. Lippmann, at the last meeting of the Academy of Science at Paris. M. Poincaré's investigations were carried out at the Laboratoire d'Enseignement Physique, à la Sorbonne.

It is well known that when a number of pieces of antimony and bismuth are arranged end to end, and the temperature so regulated that their alternate junctions are hotter and colder respectively, that there is an electromotive difference of potential between the extremities of such an arrangement, and that the E.M.F. of x pairs of such elements is x times the E.M.F. of one pair. This principle is utilised in the familiar thermo-electric pile which has proved of such assistance in so many instances of delicate research.

It is possible to make a pile in quite a different way, namely, by placing two metals of different chemical nature in a fused metallic salt, which may be raised to a temperature sufficient to cause it to conduct well. Upon such an arrangement as this M. Poincaré's investigations were undertaken, with a view to discovering whether such voltaic couples obey the laws established in the case of hydroelectric piles.

In studying this question, a knowledge of the Peltier effect due to the contact of the metal and the salt is necessary. To measure this effect directly is found to be a rather difficult matter, as it always is to estimate an inconsiderable evolution of heat in the midst of a liquid mass already at a high temperature, hence M. Poincaré contented himself with calculating the value indirectly, applying Sir William Thomson's formula :—

$$P = -\frac{T}{J}\frac{dE}{dt}$$

The electromotive force was measured by the method of compensation, using Lippmann's electrometer instead of a galvanometer.

The thermo-electric apparatus consisted of small cells of porous earthenware filled with the fused electrolyte and plunged in a bath of the same metallic salt. By a convenient process of heating, a difference between the temperatures, t and t', of the two tubes was obtained. Two wires of the same metal were wound round the bulbs of two mercury thermometers, which were graduated to 460° C., and accurately valued beforehand ; these wires dip at one end, each into one of the porous cells, and by the other they are bound to the electrometer.

In order to eliminate the effects of polarisation during the course of the experiments, it was necessary to work either with the salt of the metal employed or with a salt of another metal to which had been added a certain quantity of the same salt of the original metal. Measured in the manner and by means of the apparatus thus indicated, it was found that the thermo-electric forces had the same sign and nearly the same value as those investigated by M. Bouty in the case of saturated solutions, and described by him in the *Comptes Rendus*, t. XC., p. 217. Thus, it is proved for the case of the metal silver in the salt nitrate of silver, that the thermo-electric force, which may be designated by the symbol E, is sensibly independent of the absolute value of the temperature, and proportional to the difference $t - t'$.

For a difference of $\theta°$ measured by means of the air

thermometer, the thermo-electric force between 310° C. and 400° C, has a value given by the equation—

$$E = 0{\cdot}00027 \,.\, \theta \text{ volt}$$

In solution it has been found that the value is

$$E = 0{\cdot}00024 \,.\, \theta \text{ volt}$$

The warmer metal is in this case at the negative pole. With zinc, however, in chloride of zinc, the warmer zinc is positive and the electromotive force is = 0·00013 volt for 1° C. It is satisfactory to notice that Bouty has found exactly the same value in his experiments with highly concentrated solutions.

If the salt begins to solidify in one of the cells it has not been possible to establish alteration in the thermo-electric force, and it does not appear to matter if solidification takes place in the other. The metal itself can be brought into the liquid condition, just like bismuth can in bismuth trichloride and in this case, too, it appears to be impossible to detect any change in the value of the thermo-electric force at the moment of fusion.

When nitrate of soda is mixed with nitrate of silver the thermo-electric force at the contact of the silver varies with the weight, x, of nitrate of silver contained in 1 gramme of the mixture according to the equation—

$$E = \frac{a \times 10^{-5} \text{ volts}}{b + x} \,.\, \theta$$

where $a = 58{\cdot}16$ and $b = 1{\cdot}154$.

In this case difficulties do occur, if the salt solidifies in one of the cells, which appear to be due to differences of concentration produced by unequal solidification; in fact the existence of currents can be directly established and shown to be due to difference of concentration of the silver nitrate in the fused sodium nitrate which surrounds the two electrodes of silver. The electromotive force of such a system is able to attain 0·22 volt.

In those ordinary cases in which the law of Volta applies, the value of the Peltier effect measures the difference between the chemical heat and the voltaic heat of a reversible pile; if this difference is *nil* Helmholtz's theory (*vide Wiedemann's Annalen der Physik und Chemie*, Neue Folge, III., 1878), permits the statement that the electromotive force should be independent of temperature.

Unfortunately, for verifying this, the study of piles with fused electrolytes only allows of a limited number of couples being employed, on account of the conditions of the experiment. The thermal data are often insufficient, and there is room, moreover, for observing that the chemical heat corresponding to a reaction produced between two substances in the liquid state is able itself to vary very notably with the temperature; this was put forward by Berthelot in his *Mécanique Chimique*.

M. Poincaré confines himself to the consideration of the following simple reversible couple—

Zinc | Chloride of zinc, protochloride of tin | Tin.

The exceedingly small value of the Peltier effect at the contact of the zinc and of the chloride of zinc on the one hand, and of the tin and the protochloride of tin on the other, which is only equal to 0·000028 for 1° C, enables one to predict that the electromotive force of this pile ought not to be very different from that which can be calculated, supposing that the chemical heat is equivalent to the voltaic heat.

According to Thomsen, the heat evolved by the substitution in the chloride of an equivalent of zinc for an equivalent of tin reduced to the solid state, is 8·4 calories. When Persons's work on this question (*vide Annale de Chimie et de Physique*, 3rd série, t. XXI.), and likewise that of Berthelot, is duly considered, it becomes evident that the heat evolved ought to be about the same, but rather less, for the liquid state. By calculation, the electromotive force obtained should be—

E.M.F. = 0·363 volt.

The mean of a number of experiments, however, gave—

E.M.F. = 0·370 volt (solid state),
E.M.F. = 0·355 „ (liquid „).

On the other hand, M. Poincaré showed that between the temperatures 250° C. and 350° C. the electromotive force of the pile is almost entirely independent of the temperature. It is possible to conclude, therefore, according to a theorem of Lippmann, that the specific heat of the system does not vary according to the passage of the electricity.

If a pile be constructed so that one of the electrolytes is fused at a certain temperature whilst the other is allowed to remain solid, as, for instance, in such an arrangement as the following—

Zinc | Fused zinc chloride, solid silver chloride | Silver,

at about 300° C., it can be established that the electromotive force varies to a well-marked degree, according to the temperature. This variation is even more considerable if a tube of glass be used as one of the electrolytes. Lippmann's theorem again comes in, for the specific heat of an element varies according to the change of state produced by the current of electricity in the system.

In conclusion, M. Poincaré says that the theory of Helmholtz, with all its consequences, may be regarded as amply verified, even in the case of piles in which the electrolytes are caused to become conductors, not so much by dissolution, but by an elevation of temperature.

LIGHTNING CONDUCTORS.

By S. ALFRED VARLEY.

(*Continued from page* 289.)

Magnetic Inertia and Self-Induction.

IT can make no difference to energy itself whether it sets matter into motion bodily, or whether it sets up motion inside matter, and if, as the writer thinks, electrical transmission occurs through the medium of atomic motion, then, as matter consists of a congeries of atoms, it would seem probable that as inertia has to be overcome when the atoms of matter are all moved together, so also inertia should be encountered during the transition of the atoms of matter from a condition of rest inside the molecules to one of motion. Assuming this to be so, then when internal motion is set up in matter the inertia to be overcome would not be nearly so great as when matter is moved bodily, for what occurs is very similar to that which is observed when a billiard ball is propelled and strikes a row of billiard balls arranged in a line, the inertia of one ball only being overcome and the energy being transmitted from ball, to ball, without moving any of them with the exception of the last one, and this one becomes itself moved, by the energy imparted to it, simply because there is no receptacle into which the energy can be passed.

Energy when associated with certain modes of motion is more under control than when combined with other descriptions of motion. Take as extreme examples the transmission of energy to a distance through the medium of mechanical and electrical alternations. In both cases the energy will become dissipated eventually by radiation into space, but energy combined with electricity can be more completely dealt with, and a greater percentage of it can be made to dissipate itself through the medium of useful work, than is the case when energy is transmitted through the medium of matter which is set into motion, and whose inertia has to be overcome at each alternation as well as the friction incidental to such mode of transmitting energy.

A mental conception only of the internal structure of matter is possible, but it is conceivable that the ultimate atoms of all matter are more or less magnetically polar, and that a rearrangement of the atoms inside the molecules is brought about when electrical motion is set up, such rearrangement being similar to that commonly supposed to occur when iron becomes magnetic by induction. Inertia has to be overcome to effect a rearrangement of the atoms, and the overcoming it involves a temporary diversion of energy from transmission which becomes stored up in the conductor, and corresponds to the degree of active magnetism developed in the circuit. Such inertia may be fairly termed magnetic inertia, and, like terrestrial inertia, it increases as the mass or weight of the conductor becomes greater. Self-induction (using the term as distinguished from magnetic inertia proper) arises out of the mutual attraction of the molecules rendered magnetic at the time atomic motion is being set up in the circuit, these magnetised molecules act upon one another on their *own* account inductively, and bring about a higher degree of magnetic polarisation, in the same way as the opposite poles of a horseshoe magnet act on one another, and so raise the magnetic polarisation of the atoms throughout the magnetic circuit. This action of the magnetised molecules on one another is what the term self-induction seems to more truly express, and it is in this sense the writer always understood Prof. Hughes to have used it, at the time the attention of physicists was so strongly directed by him to the subject. Now, seeing what is commonly understood by self-induction is not necessarily relative to the amount of current passing through a circuit, and seeing also it is not electrical but magnetic induction, the term self-induction is somewhat misleading, as it does not suggest the source of self-inductive phenomena.

The effect of self-induction, using the term in the sense which has been defined, is to further increase the storage capacity of conductors, and to bring about a greater temporary diversion of energy than would otherwise occur. It is wished to lay stress on the fact that the energy temporarily diverted and which remains stored all the time the circuit is closed represents the inertia encountered in setting the atoms in motion as well as the further increment of magnetism due to the mutual magnetic induction of the magnetised atoms on one another, and, further, that the inertia encountered, the energy stored, and the active magnetism developed in the circuit, are the equivalents of one another.

Construct three copper conductors of similar weight and length, let one of them be made in the form of a thin ribbon, and let the other two be cylindrical, the magnetic inertia and conductive resistance will be the same in each, but the self-induction will be less in the ribbon than in the cylindrical conductors, and for the reason that the atoms and molecules of which the conductors are composed are as a whole farther apart in a ribbon conductor than they are in a cylindrical one, and consequently the mutual magnetic induction of the atoms rendered magnetic by the current is less in ribbon than in cylindrical conductors.

Now form one ot the two cylindrical conductors into a spiral helix; neither the resistance nor the magnetic inertia as defined by the writer will be altered, but as in a helical conductor the magnetised molecules are brought into much closer contiguity than they are in a straight conductor, the conditions are more favourable for magnetic induction occurring between them, and consequently the self-induction of a helical conductor is considerably greater than that of a straight one.

Close an electric circuit through the three conductors arranged side by side, and there will be a temporary check at the moment of closing the circuits, such check being due to the inertia opposed by the magnetic inertia proper, and self-induction, the overcoming of which involves time. This temporary check will be the greatest in the helical circuit; it will be considerably less in the straight cylindrical conductor, and least of all in the straight ribbon conductor. So soon as the inertia has been overcome, current will flow through the three circuits at an equal rate as they have each of them the same conductive resistance, but the magnetism developed in the helical conductor will be considerably more than in that of either the other two, and the magnetic polarisation that is developed in the ribbon conductor will be less than that of the straight cylindrical circuit. It will therefore be seen that the magnetism developed is by no means necessarily determined by the actual current flowing, but that the magnetism produced represents the amount of energy temporarily diverted from transmission and stored in the circuit, and therefore the energy stored in an electrical circuit and the magnetism that is produced may be regarded as convertible terms.

The magnetism capable of being developed in a helical circuit is fairly considerable, the spiral rings attracting one another and pulling them closer. If a galvanometer be included in a closed helical circuit and the rings be pulled apart and allowed to close alternately, the deflection of the needle will become temporarily greater at the time rings are being separated and the deflection will be temporarily reduced in the act of closing again. The effect of increasing the space separating the rings is to reduce the self-induction between them, the magnetic polarisation and the storage capacity become consequently less, and energy is parted with which develops a temporary current increasing the deflection.

When the rings close again the storage capacity becomes increased, energy is diverted again from transmission, and stored, raising the magnetic polarisation, and temporarily reducing the deflection of the galvanometer. The reduced deflection of the galvanometer arises from an increase of inertia in the conductor, and as this inertia opposes resistance during the time it is being overcome, there is a temporary increase of resistance in the circuit which lessens the current as indicated by the smaller galvanometer deflection.

If the three circuits be opened, arcs or sparks will be observed where the conductors are separated; these arcs are due to the circuits parting with the stored energy, and such stored energy represents the inertia opposed and overcome at the time the circuits were closed. Now, as the inertia opposed by the helical conductor was greater than that of either the other two straight conductors, the storage of energy, and the arc produced at the time it is being dissipated, will be greater on the division of this circuit than when either of the other two are divided, and for reasons similar to those already given, the arc produced by the division of the ribbon conductor will be less than that of the straight cylindrical one.

Insert a soft iron core inside the helix, and, as is well known, the inertia which has to be overcome at the time the circuit is closed will be very much greater; but the self-induction of the circuit cannot be said to have altered, for the insertion of the iron cylinder inside the helix will not affect in any way the magnetic polarisation of the helical convolutions, which will be found to attract each other just the same, whether there be iron inside the helix or not. All that would appear to have happened is the magnetisation of the iron; such magnetisation being *in addition* to the magnetism developed in the electric circuit itself. The increased inertia encountered at the time the circuit was closed, and the magnetism developed in the iron are the equivalents of additional energy stored; but it is contended that this additional storage occurs *in the iron*, and *not* in the electric circuit. It is true, no doubt, that the helical circuit through which the energy is transmitted plays an important part, and is a connecting link between the iron and the source of electrical energy, which may be a dynamo; and, further, it is also true that practically the whole of the occluded energy may be dissipated through the medium of the electric circuit; nevertheless, there seems to be no manner of doubt that the energy is stored up in the iron cylinder, for under certain well-understood conditions, nearly the whole of the occluded energy may be dissipated through the medium of current set up in the iron instead of in the electric circuit.

The energy occluded when a circuit surrounding a soft iron core is closed must be stored either in the iron, the circuit, or in both of them, and as the channel through which the dissipation of the occluded energy chiefly takes place, is determined by the conditions prevailing, the dissipation occurring sometimes almost entirely through the medium of the electric circuit, and sometimes through the medium of the iron, and generally taking place more or less through the medium of both, it follows that at the time the dissipation is occurring energy must pass either from the iron to the circuit, or from the circuit to the iron.

The question has to be faced that if magnetism developed in the soft iron core of an electro-magnet represents energy temporarily diverted from transmission by occlusion in the iron, how has it passed from the electric circuit to the iron? The energy has been transmitted (not created) by a dynamo to the convolutions of insulated wire, which must be regarded as a link joining in some way the dynamo and the iron. It cannot be denied that energy has been transmitted through space. But how? What is observed when energy passes through a row of billiard balls may help a little way, perhaps, towards a mental conception, but this does not explain the how. All that can be said with certainty is, that the study of electro-dynamics brings us very close to elementary principles, and, when physical phenomena are traced to their elementary bases, we invariably find ourselves confronted with what are, in effect, simply dogmatic utterances, which, in the opinion of the writer, it would be wiser to recognise as being so, instead of, as is now so commonly done, coining some new term or phrase, and covering up difficult problems with mathematical equations; for the first step towards knowing, is a clear, and keen perception, that, we do not know.

We have another example of the passage of energy through space in the transformer, the primary circuit being closed through a dynamo where the transformation of energy is effected, and the work being performed in the secondary circuit, electrically insulated from the primary wire.

Perform the following experiment:—Close, for a very short given interval of time, a galvanic battery through convolutions of insulated wire surrounding a soft iron core, and include a mirror galvanometer of low resistance and small self-induction in the circuit. Magnetic inertia will be overcome to a certain degree and the amount overcome will be indicated by the angle of deflection. Now, surround the primary convolutions with a secondary wire joined also through a mirror galvanometer, and close the primary circuit through the battery for the same interval as before; the writer ventures to say the deflection of the mirror galvanometer of the primary wire will be considerably greater now that it is surrounded by a secondary circuit insulated from it, and a current will at the same time be also set up in the secondary wire; and, further, if the primary and secondary circuits have a similar number of convolutions, and if, in addition to having but little magnetic inertia, their conductive resistance is low compared with the resistance in the battery, then the additional current produced in the secondary circuit will very nearly, if it does not indeed practically, equal that developed in the primary wire.

Now, the increased current developed in the primary circuit, and that which was developed in addition to it in the secondary convolutions, must have been produced by energy unlocked in the battery; that being so, it is evident that the surrounding the primary wire with a secondary one has reduced the resistance to a sudden transmission of energy, and by doing so has enabled the galvanic battery to unlock energy more quickly. This action of the secondary circuit, it is thought, throws light on the part played by the iron core.

The electrical transmission of energy would seem to be effected through the medium of internal motion set up in the conductor, and iron inside a helical circuit has evidently the property during the time it is occluding energy and becoming magnetised of creating resistance in the electrical circuit, and so checking the transmission of energy through it.

What occurs is not altogether unlike that which happens when a ball is thrown against some hard substance and rebounds; when a ball rebounds the energy of motion is not parted with—what occurs is simply a change in the direction of motion. Now, when a battery is closed through a primary circuit, wrapped round a soft iron core, the energy may be regarded as striking or pushing against the iron and becoming occluded in the act of magnetising it; the inertia of the iron, however, resists a sudden assumption of the magnetised condition, and, as a consequence, something of the nature of a recoil is the result; but, as there is only one conducting channel, a rebound means the setting up internal motion in the circuit in the opposite direction to that which chemical action in the battery is endeavouring to develop, and the effect is to check the chemical action which, consequently, does not proceed in the battery so actively as it otherwise would. When, however, there is also surrounding the iron a secondary circuit, the magnetic inertia of which is very small compared with that of the iron core, there is then a neutral conducting channel through which the energy whose development has been checked by the inertia of the iron can find an outlet by developing an electric current, and if the secondary circuit in addition to having but little magnetic inertia opposes but little conductive resistance, then the iron inside the helical circuits will have scarcely any influence on the development of energy, and chemical action will proceed actively in the galvanic battery, and not be checked appreciably by the magnetic inertia of the iron core.

It cannot be considered at all correct to speak of a rebound of energy, but still what occurs when secondary currents are developed is very analogous to what takes place when a ball rebounds, the ball changes its direction of motion instead of parting with energy and the change in the direction of motion is brought about by the positive energy which has been imparted to the ball, being resisted by the negative energy or inertia of the matter it strikes against, but in the case of energy being transmitted by rapid electrical alternations, the change of the direction of motion brought about by the inertia of the iron core occurs in the secondary wire, in which it sets up a current to enable the development and transmission of energy to proceed.*

If the conductive resistance of the secondary circuit be not taken into account, it will be seen that the current developed in the secondary circuit must have relation to the inertia opposed by the secondary circuit, as compared with that which the iron opposes, for if the inertia of the secondary circuit were, say the same as that of the iron, it would check a sudden transmission of energy equally with the iron core; it must also, the writer thinks, be seen that the current developed in a secondary circuit is, instead of magnetic polarisation, being produced in the iron core, he would lay stress on this fact because although it seems to him no other conclusion can be come to, the writer's view has been ridiculed by at least one of our popular mathematical physicists.

Figs. 11 and 12 * represent two vessels made of thin metal containing water, both of which are assumed to have the same sectional area, and their object is to illustrate mechanically magnetic inertia and self-induction. Let the two pointed cylinders represented in the figures be propelled at a high rate of velocity through the water and the bottoms of the vessels, and assume they make an air tight joint in their passage, and that the orifices made in the bases of the two vessels close

* The fact that energy would appear to be capable of only leaving any vehicle it is associated with by passing into another suggests the query whether heat radiation does not require not only matter from which the radiation emanates, but also matter to radiate into, and if so, energy would leave the sun and radiate throughout space, only so far as there is matter in space to receive and occlude the energy.

* These blocks were inadvertently inserted in last week's matter.—EDS. ELEC. REV.

immediately the cylinders have passed through, inertia and skin resistance will be encountered as the cylinders pass through the water, the level of which will become raised by displacement, lateral pressure will also be exerted on the sides of the vessels and ring waves will be formed on the surfaces of the water.

The rectangular vessel will oppose less resistance than the round one to the passage of the cylinder because the rectangular shape permits the sides to bulge out freely, whereas the cylindrical shape does not do so, and as the sides of the cylindrical vessel resist bulging out the passage of the cylinder through it raises the water to a higher level than is the case with the rectangular vessel, and after the cylinder has passed through there is also a greater fall at the time the water is reassuming its normal level.

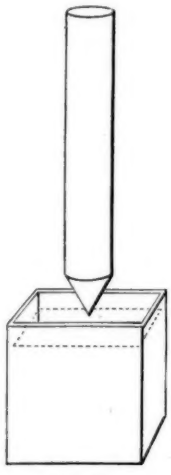


FIG. 11.

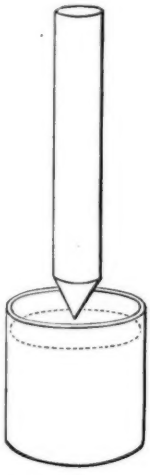


FIG. 12.

The rectangular vessel may be regarded as representing a ribbon conductor and the round vessel a cylindrical one, the higher level to which the water becomes raised in the round vessel represents the greater check and greater storage of energy which occurs in cylindrical conductors, and the drop from a higher level represents the greater amount of extra current developed when the circuit through a cylindrical conductor is divided than occurs on the division of a ribbon circuit of the same length and similar conductive resistance.

The illustrations above given are admittedly crude and imperfect, but they serve to illustrate the general principle, and the writer feels confident they will be found to harmonise with what is observed in connection with electrical transmission for all physical phenomena are referable to motion and all modes of motion are traceable to a common origin.

In previous articles, attention has been directed to the similarity existing between terrestrial and magnetic attraction. All conductors have magnetic inertia but iron possesses it to a degree incomparably greater than any other conducting substance. It may be put in this way, if the specific gravity of matter were expressed in terms of magnetic, instead of terrestrial gravity, then iron would be by far the densest of substances.

Magnetic inertia could be conveniently dispensed with in conductors, but the writer has always considered, and he still contends that magnetic inertia should be regarded as the material basis of the dynamo,* and further, he ventures to maintain that were it not that iron possesses magnetic inertia in so large a degree relatively to other conducting matter, there would be neither dynamos nor transformers.

It may be as well to emphasise at this place what is recognised, but not so much, it is thought, as it should be, viz., that mechanical machines, dynamos and transformers simply transmit, transform, and alter the potential of energy.

The dynamo is both the simplest and theoretically the most perfect of machines, for it deals more directly than other machines do, with the two elementary principles which underlie all physical phenomena, viz., energy the source of *all* force and inertia *the principle* of matter as contrasted with that of force.

The distinctive difference between steam engines and other machines for developing force, and the dynamo lies in the fact that terrestrial inertia forms the basis or resisting fulcrum of all mechanical machines, whereas magnetic inertia is the resisting fulcrum of the dynamo.

The fulcrum available for the mechanical engineer is practically infinite, for the reason that terrestrial inertia so greatly exceeds any force capable of being developed by a machine, and it also costs nothing, but the fulcrum at the command of the electrical engineer is far from being practically infinite, for the largest dynamo consists of but a very moderate quantity of matter, and, moreover, the efficiency of a dynamo is, after all, simply the difference between the respective magnetic weights of the iron of the field magnets and that of its moving parts.

The inertia that is capable of being developed in a dynamo is limited, and is ultimately determined by the weight of the field magnets.

(*To be continued.*)

* In the earliest published reference to the writer's original dynamo of 1866, the first self-exciting machine constructed, he described the dynamo principle as the discovery that the small trace of active magnetism resident in the ordinary iron of commerce, could be used as a fulcrum for mechanical force to act upon, not only to develop electricity, like an ordinary magneto machine in the way discovered by Faraday, but also in such a manner as to exalt the magnetism in the iron of the dynamo machine itself, so that as long as mechanical force was being consumed in imparting motion to the machine, the iron which, when the machine was at rest, might be regarded as magnetically passive, became magnetised to the highest degree, and produced electricity in quantities corresponding to the magnetic exaltation developed in the machine.

THE AGRICULTURAL HALL EXHIBITION.

THE International Exhibition of Machinery, Manufactures, Appliances, and Inventions incidental to Engineers, Electricians, Builders, and Ironmongers, was opened on Monday at the Agricultural Hall, Islington, and will close next Saturday. The number of exhibitors is 177; but on the opening day the exhibits were in a backward state, the usual occurrence at exhibitions of this kind. From an electrical point of view, it is disappointing, as few electrical firms are participating in it; but general engineering is fairly well represented.

Messrs. Crossley Brothers, Limited, show four Otto gas engines of 2 H.P., 3 H.P., 4 H.P., and 14 H.P. respectively. The 14 H.P. engine is shown driving a Thomson-Houston dynamo, supplied by Messrs. Laing, Wharton and Down.

The dynamo has an output of 6·8 ampères at 1,200 volts pressure, whilst running at 900 revolutions, and supplies current to 30 1,200-C.P. arc lamps, arranged above the stand in two rows. This stand is one of the chief attractions in the exhibition, owing to the amount of light diffused when the dynamo is running in the evening.

The British Gas Engine and Engineering Company, Limited, exhibit two Atkinson's "Cycle" gas engines, of 1 H.P. and 4 H.P. respectively. The 4 H.P. gas engine drives a Statter dynamo running at 1,200 revolutions, the output being 40 ampères at 60 volts E.M.F. The dynamo supplies current to four arc and a few glow lamps, placed on and above the stand.

Messrs. J. E. H. Andrew and Company, Limited, have on view one ½-H.P. Bisschop gas engine and three Stockport gas engines, one of 1 H.P., the second of 6 H.P., and the third of 8 H.P. The latter actuates a

Phœnix dynamo supplied by Messrs. Paterson and Cooper, and running at 600 revolutions. The dynamo gives 10 ampères, and feeds 7 Phœnix arc lamps fixed above the stand. The current is first led through an ammeter placed on the wall, and then through a series of resistance coils to the lamps.

Messrs. Dick Kerr & Co. exhibit several Griffen gas engines of the horizontal and vertical types. One engine is employed to drive an Excelsior dynamo, supplying current to a Kent arc lamp of 4,000 C.P., suspended from the roof of the hall. A 12 H.P. Griffin gas engine is shown operating a Tyne dynamo of 100 ampères and 60 volts, the speed being 1,170 revolutions. This dynamo supplies current to 12 Kent arc lamps of 4,000 C.P., suspended from the roof and lighting up the body of the hall. These lamps comprise the whole of the official electric lighting, gas being also employed to light the building. It was originally intended to illuminate the entire place by electricity, and for this purpose a prize of £100 was offered; but as no tenders were sent in, it was eventually decided to only use the electric light for a portion of the building, the installation comprising, as already mentioned, only 13 arc lamps.

Messrs. O. Berend and Co. have a pretty display of electroliers, chandeliers, wall brackets, hall lamps, table lamps, &c, and volt and ammeters. Most of these are of German make. The design of the electroliers is of high-class and finish, they being made principally of brass, brass and copper and hammered iron.

The Consolidated Telephone Construction and Maintenance Company, show a variety of telephones, including the Gower-Bell portable telephone for field or military purposes, diving apparatus telephones, cell bells, relays, switches, &c. The exhibits are arranged in a very compact form, likely to attract visitors.

Messrs. Winnall, Callow and Winnall exhibit ten Newall high speed engines of various horse powers. A 10 H.P. Newall engine is shown operating a Phœnix dynamo running at 1,600 revolutions and supplying current to 30 16-C.P. glow lamps. The output of the dynamo is 30 ampères at 100 volts. The firm also exhibit various kinds of electric bells, including the Watt bell for use in factories, church, schools, &c.

The Weymersch Electric Battery Syndicate have a very attractive stand. This company has, doubtless, the most interesting electric lighting exhibits in the exhibition. From the roof of the stand is suspended a 400 C.P. Planet arc lamp which is fed with current by five sets of six cells each, run in series, the output of the thirty cells being 6 ampères at 45 volts pressure. A small motor of about one-eighth H.P. is shown driving a fan, and supplied with current from a set of cells giving 10 ampères at 10 volts. Five sets of six cells furnish energy to 20 8-C.P. lamps fixed in highly finished standards. There is also on view a number of artistic fittings made of copper, brass, copper and brass and hammered iron; also an elaborate assortment of fancy table lamps, standards and electroliers. In addition to these exhibits, the firm has a set of cells running a 16 C.P. lamp fixed in Allday's and Onion's office, and a set of cells used in connection with Messrs. Pyke and Barnett's vacuum tube and transformers.

Messrs. Pyke and Barnett show their patent flame spark transformers, flame spark coils, condensers, spark coil breaks, and their method of working vacuum tubes in parallel, with which the previously mentioned Weymersch battery is used.

Electric Tramway Schemes.—The subject of subdivided conductors for electric tramways seems likely to develop into another of those undesirable *contre-temps* in which lawyers, and not inventors, reap the benefit. Perhaps we shall yet have Mr. Holroyd Smith taking part in the matter on the strength of Mr. Wilkinson's communication.

REVIEW.

Electrical Engineering for Electric Light Artizans and Students (embracing those branches prescribed in the syllabus issued by the City and Guilds' Technical Institute). By W. SLINGO and A. BROOKER. With 307 illustrations. London: Longmans, Green and Co.

The authors of this work are well-known officers of the Postal Telegraph Service, having for many years past conducted a highly successful Telegraphists' School of Science in connection with the instrument gallery of the General Post Office: they are also known as managers of the Electrical Engineering Section of the Peoples' Palace.

In prefacing their book the writers practically state that their work is an attempt to cover the whole field of electric lighting, especially with reference to the extensive syllabus of the City and Guilds of the London Institute. The headings of the various chapters are as follows:—I. Current, Potential, Conductors, Insulators; II. Practical Units, Ohm's Law, Fundamental Units; III. Primary Batteries; IV. Measurement of Current Strength; V. Measurement of Resistance; VI. Measurement of Electromotive Force; VII. Electro-magnets, Electro-magnetic Induction; VIII. Dynamo-electric Machines (Alternate Current); IX. and X. Dynamo-electric Machines (Direct Current); XI. Direct Current Dynamos (Open Coil); XII. Motors and their Applications; XIII. Transformers; XIV. Secondary Batteries; XV. Arc Lamps; XVI. Incandescent Lamps, Photometry; XVII. Installation Equipment, Fitting, &c.

The general style of treatment of the subjects dealt with in the opening chapters is, in many respects, novel, and is decidedly commendable; the reasoning, however, is not always such as would, we think, give a student a distinct understanding of what is meant; thus, in speaking of an electrified sphere, it is stated that the lines of force radiate inwards if the charge is negative; this, we should say, would give the student (in the absence of an illustration) the notion that a body brought near the sphere would not be affected, as the lines of force would all be inside the sphere. In fact the idea of lines of force is one which requires considerable illustration in order to make it really comprehensible. In speaking of potential we are told "where there is no difference of potential there can be no flow of electricity;" with reference to this we would quote the following from the late Prof. Fleming Jenkins's "Electricity and Magnetism." The Professor says: "Wherever difference of potential is found there must therefore be an electromotive force, but we shall see (Chapter III., sec. 22) that there are cases in which electricity is set in motion from one point to another, between which that difference of condition does not exist which we have defined as difference of potential;" precisely speaking, therefore, Messrs. Slingo and Brooker's statement requires reservation. Coming now to Chapter II. we note that "most telegraph apparatus continues to be measured by the B.A. unit, while the apparatus employed in the newer industries, such as electric lighting, is measured by the legal ohm." This statement, we fancy, is hardly a correct one, and we do not know upon what authority it is made. In their definition of "current strength" the writers are unfortunate; that "by current strength is meant *the amount or volume of electricity passing any point in a circuit at any particular moment*," is certainly not correct; *rate* of flow involves a definite *interval* of time, not a definite time or "moment" of time; however, the authors give in the succeeding paragraphs a very lucid explanation of the subject, which prevents the incorrect definition referred to from being misleading. Indeed, with few exceptions, the whole of the matter is admirably adapted for the purpose of giving students and others a very clear insight indeed into the subject treated of.

Chapter III., which deals with primary batteries, is exceedingly good; we observe, however, that the authors state that the cells in use at the Greenwich Royal

Observatory (which cells are used for driving clocks) are zinc carbon couples, the carbon being plain gas retort carbon; this is a mistake, as these cells are actually the Walker pattern (used on the South-Eastern Railway), in which platinised carbon is employed, the zinc being immersed at its lower end in a slipper of mercury. We may mention that the Walker form of cell is found to be admirably adapted for the purpose, probably on account of the fact that the simple sulphuric acid and water which is used as the excitant is not a fluid which tends to decompose by local action, whilst, at the same time, it is a solution which has a low resistance. In referring to amalgamated zinc the authors rather lead one to suppose that the zinc plates for ordinary Daniell telegraph batteries would be treated in this way; as a matter of fact, this is not the case, as amalgamation in such batteries is not found to be of any advantage, whilst, of course, it is a comparatively expensive process.

In Chapter IV. the authors point out that although the strength of action between solenoids is greatly increased by fitting them with iron cores yet the electro-magnetic force itself is not in the slightest degree augmented, this is a point which we do not recollect to have seen insisted upon in other works, though it is an important one, and the writers have done well in enforcing it so strongly as they have.

In Chapter V. we have very good descriptions of methods and instruments for measuring resistance, and in Chapter VI. electromotive force is equally satisfactorily dealt with. Coming now to Chapter VII., in which electro-magnetism is dealt with, we were much struck with the extreme clearness and eminently practical character of the explanations. We note that in describing the winding of an electro-magnet bobbin the writers point out (what no other book does) that the various turns of wire cannot lie in the recesses or grooves between the turns of the layer immediately beneath, as is often assumed to be the case. This fact was, we believe, first called attention to by Prof. Ayrton in a discussion before the Institution of Electrical Engineers.

(*To be continued.*)

LEAD-COVERED CABLES AND CREOSOTE.

THE deterioration of lead pipes placed in creosoted modern conduits, due to the action of "phenols," has been on more than one occasion alluded to in these columns. This action has been particularly noticed in the conduits belonging to the Telephone Company in Brooklyn, U.S., and reference to the annual reports of Mr. Sargent, the company's engineer, will show the progress made in this action. Whilst the last report showed that the decay had practically stopped, it also pointed out that the action was due to "phenols," the volatile constituents of creosote oil used. It is fair to assume that the stoppage of the decay was simply due to the volatile agent having at length disappeared, leaving the creosote harmless. In a paper just published in the *Electrical World* by Mr. F. C. Prindle, C.E., on the "Evaporation of Phenols, &c., from Creosoted Timber," the author intimates that the trouble caused by this action of creosote can be almost entirely removed by the employment of the proper creosote oil from which the volatile constituents have been removed; or, in other words, by using a quality of oil in which those volatile constituents are not present at all. As it may not be improbable that at some future time it will be found convenient with our engineers to place leaden pipes in wooden conduits, which, for durability, it may be considered desirable to creosote. The experience of our trans-Atlantic friends should be borne in mind, and care should be exercised as to the quality of creosote oil employed.

TRACTIVE FORCE OF LEATHER BELTS ON PULLEY FACES.*

By SCOTT A. SMITH, PROVIDENCE, R.I.

IT is of the highest value to users of leather belts to know the exact conditions which give the greatest tractive force of belts on pulley faces; in immediate connection with this, it is essential to have knowledge of what constitutes the best leather belting.

It is the opinion of the writer that the best belts are made from all oak-tanned leather, and curried with the use of cod oil and tallow, all to be of superior quality. Such belts have continued in use thirty or forty years when used as simple driving belts, driving a proper amount of power, and having had suitable care.

In the best methods of currying, only a very small quantity of the stearine of tallow enters into the leather; the oleine of the tallow and cod oil, during a period of four weeks employed in a suitable currying process, oxidise under the influence of heat, moisture and much hand and machine labour intelligently used, and become, or partake of the nature of a gum or varnish, most intimately united with fibres which interlace in all directions.

Such leather contains no free oil, which would, if of animal or vegetable origin, have a natural tendency to generate free acid injurious to the fibres. Belt leather thus made has a supple character, with a little elasticity and compressibility which eminently fits it for tractive use on a pulley face.

When a new belt is put to use with the flesh side to the pulley, there is on it a certain quantity of stearine from the tallow (rubbed down to give smoothness to that side); this grease acts, or aids, by increasing the surface of contact, to give an extra tractive quality to the leather. If the grain side is run to the pulley face, then, in the first use of the belt, there is more tendency to slip, owing to the absence of grease on the surface, and also to the fact that the grain is hard; and in case of small diameters of pulleys, the belt face is wrinkled, thus it is less in a condition to be brought into intimate contact, under pressure, with the pulley face over its whole contact surface, than is the softer flesh side. The stearine on the surface of the flesh side, and the softness of its face, operate to exclude air from between the two surfaces, thus affording the benefit of atmospheric pressure, the strongest element in its tractive force, to hold the belt to the pulley face. In addition, when the two surfaces of leather and iron come together, on one or both of which there is a semi-fluid to interpenetrate into the pores of the two faces (providing there is a minimum of this material, or only sufficient for this interpenetration) then this material becomes an impediment to the slipping of the belt to the extent of the cohesion to, or affinity for, the iron and leather.

This statement, in relation to the action of stearine on the flesh side of leather, and the running of that side to a pulley face, is not given in the sense of an approval of either the one or the other, but to illustrate by a familiar fact. Stearine has no legitimate place on, or in, leather; also the flesh side should not be run to the pulley face, for the reason that the wear from contact with the pulley should come on the grain side, as that surface of the belt is much weaker in it tensile strength than the flesh side; also as the grain is hard it is more enduring for the wear of attrition; further, if the grain is actually worn off, then the belt may not suffer, in its integrity, from a ready tendency of the hard grain side to crack.

The most intimate contact of a belt with a pulley comes—first, in the smoothness of a pulley face, including freedom from ridges and hollows left by turning tools. Second: In the smoothness of the surface and evenness in the texture, or body, of a belt. Third: In having the crown of the driving and receiving pulleys exactly alike; as nearly so as is practicable, in a commercial sense. Fourth: In having the crown of pulleys not over $\frac{1}{4}$" for a 24" face, that is to say, that the pulley is not to be over $\frac{1}{4}$" larger in diameter in its centre. Fifth: In having the crown other than two planes meeting at the centre. Sixth: The use of any material on, or in, a belt, in addition to those necessarily used in the currying process, to keep them pliable or increase their tractive quality, should wholly depend upon the exigencies arising in the use of belts; and the use of such material may justly be governed by this idea, that it is safer to sin in non-use than in over-use. Seventh: With reference to the lacing of belts, it seems to be a good practice to cut the ends to a convex shape by using a former, so that there may be a nearly uniform stress on the lacing through the centre as compared with the edges. For a belt 10" wide, the centre of each should recede 1 10".

An impediment to the just use of leather belting, in minor cases, comes from the fact that many manufacturers of machinery will adhere to the custom of putting too small receiving pulleys on to their machines, to indicate to the purchaser that little power is required to operate them. I have a feeling of pride in having the acquaintance of an eminently practical man who takes off a pulley 6" diameter by 4" face on a circular saw arbor, and substitutes a pulley 9" in diameter by 6" face.

A few words as to hemlock tanned leather, or leather tanned by the use of half hemlock and half oak bark. I do not consider them as worthy of much consideration, as many makers of that class of belting stock have been obliged to abandon its manufacture during the past forty years. It is a less costly and less

* Presented at the 19th Meeting, Erie, Pa, 1889, American Society of Mechanical Engineers.

enduring product. It goes without saying that a well-made "hemlock" belt is better than a poorly-made "oak" belt; duly considering all the processes involved in the making of each.

I would maintain that a skilled maker of oak-tanned belting can meet any and all legitimate requirements, whatever they may be. Some uses of a belt demand that it shall be much softer than for other purposes; some that it shall be elastic; other cases need a very rigid and non-elastic belt. For quarter-twist belts, owing to the firmness of oak-tanned leather, the belts should be specially shaped by the maker for that use, both in the length of the belt and at the ends.

Referring again to the subject of oils on leather; mineral oils always act to negative oxidations of the oils in the currying process; hence they are detrimental for that use. If added after the currying process is completed, then they tend to undo the currying by softening the oxidised oils.

A question not to be ignored relates to the action of air and other influences in keeping belts from full contact with the top side of a receiving pulley, when belts are run at very high speeds; this is caused by the massing of air at this point; by excessive crowns in pulleys, giving much convexity to the belt to hold air on or in its concave side; by the rigid character of many belts, and by centrifugal force.

Much leather belting is made, which, when finished, has a very rigid character. It has gone into the hands of users in that condition for these reasons: First, because a desire has grown with some users to have belts extremely rigid against stretching—apparently forgetting that such rigidity ensures that a belt shall have a comparatively short life. Second, to make a belt very supple and very uniform, in its body, and over its whole surface, necessitates expensive methods in currying. The continued demand for lower and lower prices has induced the leaving out of that amount of careful hand-labour which always gives suppleness to leather, if otherwise well qualified; and in place of it has come a "machine" surface finish, which, to the eye, passes for the genuine article. This suppleness—sometimes called mellowness—gives to the leather due pliability, and such belts run satisfactorily at high speeds.

While the "suppleness" of belt leather has been denominated "mellowness," it should be stated that there is a resistance to flexion, in the best leather, due to its components of fibres, interlaced, in all directions, and a body of flexible gum, which, while it readily bends, yet it as readily returns to its initial shape; but the best is fully appreciated only through experience.

Rigid belts are sometimes made pliable by saturation with "belt oil," but the inevitable result, in time, is a disorganised belt; slipping will come, and the addition of more oil only results in its acting as a lubricant, by piling up on the surface.

There is some doubt in my mind as to the desirability of perforating belts, or the drilling of pulley faces, to overcome the difficulty mentioned, so far as it comes from the air, which is not so much a real difficulty when properly made belts are used as it is with the rigid belts.

Free oils added to curried leather, give "momentary" added strength by filling all the pores to distention, thus locking fibres to place; and by softening the fibres and allowing a strain—for instance, at lace holes—to be distributed over very many fibres.

As friction is due—largely—to the unevenness of two surfaces in contact under motion, and as the best tractive quality of belts comes from the evenness and smoothness of the two surfaces of belt and pulley face, it easily follows, from what I have said, that the value of the tractive force of a belt on a pulley face is due, first, to atmospheric pressure; second, to the tractive adhesion of the leather fibres and the oxidised oil of the currying process.

NOTES.

Electric Lighting at Bath.—Owing to numerous unforeseen difficulties which have arisen in connection with the laying of underground electric light mains at Bath, Mr. Massingham has found it impossible to complete the work by the date already fixed, namely, March 25th. Upon his application, the Bath Town Council have sanctioned an extension of time, so that his contract with the Corporation for public lamps, to run for seven years, will now date from June 24th. "The additional three months' time," says Mr. Massingham, "will enable me to complete the whole of the area, and allow a short period for testing the underground mains, &c., before the public lamps are permanently lighted, which is very desirable. It will also be more convenient to the public that the removal of the gas lamps should take place as near the longest day as possible."

Electric Lighting at Weybridge.—The electric lighting arrangements here have given entire satisfaction, and favourable reports have been received from several leading persons in the place.

Glasgow Overhead Electric Light Wires.—At the recent meeting of the Town Council the minutes of the Special Committee on Overhead Electric Light Cables and Wires, containing a report by Mr. David Cook, electrician, were submitted. Mr. Cook summarised the question thus:—"1. When the alterations specified by Major Cardew have been carried out (which the inspector himself will presumably see to), the overhead wires in this city will not be dangerous under ordinary conditions. 2. But as overhead high-pressure electric light wires, no matter how erected, may become dangerous—particularly to firemen—by contingencies that are not at all improbable, the further extension of the system should be discouraged, and facilities granted for placing all conductors underground. Powers for dealing with this will probably be contained, as is usually the case, in the provisional order and private Act, which the Corporation will have in their hands in the course of this year. 3. As a consequence of the action already taken by the Police Board, control of these wires has practically been assumed by the Board of Trade, in whom is vested all executive control with regard to them. It therefore seems a natural assumption that no responsibility can now attach to the local authority in case of accident, but this is a point upon which I am not competent to offer an opinion." The committee, having considered the report, agreed to recommend that a copy thereof be forwarded to the Board of Trade, and their attention directed thereto. On the motion of Bailie Gray, the minutes were adopted. The minutes of the same committee contained a report by Mr. Cook on the recent fire and accident at Messrs. Sorley's. Mr. Cook reported:—"The fire, and accident to the fireman, were both due to leakage of the high potential electricity used for lighting Messrs. Sorley's shop, and the leakage was caused by the men on the job scamping their work at a place where it was exceedingly difficult of detection. Moreover, the faulty conductors were arranged in contravention of rules issued by the Institution of Electrical Engineers and Insurance Companies for the prevention of fires. With these exceptions, all the work was well executed, the overhead arrangements conforming fully with the Board of Trade regulations." The committee directed that a copy should be sent to the Board of Trade. The minutes were adopted.

Private Electric Lighting.—Perhaps the most successful installation of the electric light for private purposes yet carried out in Ireland is that just completed at Grove House, in the County Tipperary, the residence of Mr. R. Burke, Master of the Tipperary Fox Hounds, and referred to in our "Notes" of November last. Not only is the dwelling house brilliantly lighted in every part by some 80 or 90 incandescent lamps, but the outoffices, and especially the stables and kennels, are conveniently provided with lamps and switches whereby the light can be readily turned on and off at pleasure. The importance of the electric light for lighting stables is at once apparent when it is remembered the danger attending the use of oil or candles; and in the case under notice, where some 25 of the finest hunters to be found in the sister-country are carefully installed, the advantages attending the new illuminant are warmly appreciated. The installation, which has been carried out to the specification and under the immediate superintendence of Messrs. J. K. Fahie & Son, the well known firm of electrical engineers, of Dublin, consists of a dynamo of the Elwell-Parker type driven by a vertical steam engine, and a storage battery is provided which renders the light available when the dynamo is not running.

Electric Light in Spain.—We learn that the Thomson-Houston Company has completed, for the Municipal Council of Bilbao, an electric light installation of 46 lamps of 2,000 candle-power. Great satisfaction is expressed with the brilliance and steadiness of the illumination.

Edinburgh Royal Society.—The eighth meeting of the present session of the Royal Society of Edinburgh was held on Monday in the Royal Institution, Sir William Thomson, President, in the chair. The president read a paper recounting an accidental illustration of the effective ohmic resistance to a transient electric current through a steel bar. He said that at the recent meeting of the British Association at Newcastle Sir William Armstrong told him of a wonderful incident. A bar of steel about a foot long which he was holding in his hand was allowed accidently to come in contact with the two poles of a dynamo in action. He instantly felt a painful sensation of burning, and he let the bar drop. He found his fingers where they had been in contact with the bar severely blistered. The bar was found immediately afterwards to be quite cold. This proved the outer surface of the steel to have been intensely heated, and that not enough of heat was generated to sensibly warm the whole bar. The explanation was to be found in the known laws of diffusion of electric currents through conductors. It seemed to him (the President) to be an illustration of the fundamental principles of electro-magnetic induction, and he had got permission to communicate the facts to the Society. Lord Armstrong had sent him the bar and some further details. There were two hollows burned out of the metal at the points where the bar touched the poles of the dynamo. Lord Armstrong had held the bar midway between the two marks. It was perfectly cold three or four seconds after he dropped it. The dynamo gave an alternate current of 85 ampères, with a potential of 103 volts. The President did not think this accident alone would prevent electricians from burning their fingers, but that the same experience would have to be gone through by many before caution was learned. The facts were—an exceedingly high temperature for an exceedingly short time in an exceedingly thin skin of metal. The President then showed how the theory involved could be worked out by Maxwell's fundamental equations of electro-magnetism.

Government and the Telephones.—In the House of Lords the Duke of Marlborough asked H.M.'s Government whether they had any intention, on the expiry of the English telephone patents, to inquire into the question of overhead wiring, and whether they thought it advisable that the Post Office should adopt and extend the telephone system in the Metropolis and between large towns, or failing any such intention, they would be prepared to grant to public companies the rights which the Postmaster-General now possessed, and would refrain from granting those rights to more than two companies. In reply, Lord Balfour said he recognised the great importance of the subject; he was authorised to say that the relations between the Post Office and the telephone companies were under consideration of the Government, but, as they involved large questions of private right, it was not desirable at that stage of the matter that they should form the subject of investigation by a committee. The Duke of Marlborough, in reply, pressed upon the Government the great desirability of making public as soon as possible the line of conduct they meant to adopt.

The Electro-Harmonic Society.—The programme for the last smoking concert of this season can be seen on page 11 of our supplement. With such vocal and instrumental selections, none of which are likely to prove in the least degree tedious to the audience, and with Dr. John Hopkinson, F.R.S, in the chair, we anticipate an evening's enjoyment, both musically and socially, such as has never yet been the lot of the young society to witness. It is to be hoped that members will use their best endeavours to be in their places at the hour appointed for commencing, for nothing is more disheartening to artistes than playing or singing to an almost empty room.

A New Electrical Treatise.—The first number of *Practical Electrical Engineering* has made its appearance, and the work is to be completed in eighteen monthly parts. Three chapters are completed, one on "General Principles," another on the "Conductive Circuit," and, finally, on the "Magnetic Circuit. Several excellent sheets of drawings illustrating dynamos, arc lamps, travelling cranes and electric light fittings are added, but it is questionable whether it is wise to interpolate pictures which are not referred to in the text. The writers who have been engaged to compile special portions of the work are, with one or two exceptions, authorities in electrotechnics, and the book when finished will no doubt bear out its claim to being a complete treatise on the construction and management of electrical apparatus as used in electric lighting and transmission of power.

A Presentation.—An interesting ceremony took place at the Reindeer Hotel, Newcastle-on-Tyne, on Saturday, March 8th. Mr. J. G. Moon having resigned his appointment of works manager to Messrs. J. H. Holmes and Co., electric light engineers of that city, the *employés* of the firm, to show their esteem and regret at his leaving, presented him with a very handsome Ormolu clock and vases of considerable value. We understand that Mr. Moon has accepted the position of works manager to Messrs. J. G. Statter & Co., of West Drayton.

Arc Lamps.—The success of the Brockie-Pell arc lamp must have been phenomenal for it has induced Messrs. Johnson and Phillips to issue an elegantly arranged catalogue of over thirty pages devoted to this lamp and carbons alone. A list of users, the opinions of the press and electrical experts, instructions, telegram codes, price lists and numbers of illustrations, make this catalogue invaluable to those who intend to employ arc lighting.

Victorian Schanschieff Company.—The *Melbourne Argus* says that the Victorian Schanschieff Electric Light and Power Company, Limited, has gone into liquidation. We trust that Miss Cornell has not suffered very severely.

Reproducing a Speaker.—Mr. T. A. Edison is reported to be at work on an apparatus for photographing a speaker who is using the phonograph, so that the two "records" may be produced together. He is said to have already a number of successful dual reproductions of this kind.

Utilising the Potomac Falls.—It is proposed, says the Baltimore *Manufacturers' Record*, to use the great falls of the Potomac river, 16 miles above the city, to force compressed air to the city to operate electric light plants by pneumatic power.

An Advertiser's Tribute to the Electrical Press.—At a meeting of business men recently held in Chicago, a prominently successful "supply man" remarked:—"It is the broad and liberal policy pursued by electrical journals that has done more than all else combined to build up the unparalled prosperity of the electrical industries, and to place them in the front rank of commercial industries." Referring to his heavy advertising expenses, he said:—"Of course it costs money to advertise, but for every dollar I have paid out I have received two, yes, sometimes ten-fold in return. . . . . Liberal advertising not only stimulates purchasing, but also stimulates hesitating capitalists into making new investments that in turn benefit all."

Personal.—Mr. C. R. Heap, formerly with Messrs. R. E. Crompton & Co., has recently joined Messrs. Sharp and Kent.

Where were the Electric Wires?—The burning of Toronto University was caused by the falling of an *oil lamp*. An hour later 2,000 guests would have been in the building attending the *fête*. What an opportunity missed for electricity!

The Progress of Telephony in the West.—The Western Counties and South Wales Telephone Company are proposing to erect a trunk line between Plymouth, Yelverton and Horrabridge, and to continue it on to Tavistock, Gunnislake and Calstock. In the event of sufficient public support being accorded to the scheme, these towns will be placed in telephonic communication with Plymouth, Torquay, Totnes, Dartmouth, Brixham, Newton Abbot and intermediate towns, with the prospect, later on, of a connection between all the towns from Newton Abbot to Bristol. At a well-attended public meeting which was held at Tavistock last week, the company's local superintendent stated that if the inhabitants of Tavistock enabled the company to connect their town with Plymouth, they would before many months had passed, be able to speak to any place in the United Kingdom connected with the company's system. Before, however, the company incurred the expense of establishing a trunk line, it was proposed to establish local exchanges at Tavistock and the other places mentioned. As soon as not less than 12 local subscribers were obtained for Tavistock and Horrabridge each, the company would open the exchanges and commence to erect the trunk line.

Electricity in Art.—Bartholdi, the sculptor, has completed a sketch for the monument which it is proposed to erect in the square Saint Pierre, Paris, to commemorate the part played by balloons during the siege. The difficulty was to design a balloon of natural proportions, whilst omitting some of the details. The artist has solved it in the following way: The balloon is composed of an envelope of thick glass, the netting is of iron, and the interior will be occupied by an immense electric lamp, sufficient to light up the entire place.

Anderson, Campbell, and Munro, Limited.—The company will have a capital of £10,000, in 2,000 shares of £5 each, of which 300 fully paid up will be allotted to the partners of the firm, the vendors, as full payment of the purchase price of the concern. As it has been arranged to only issue 1,000 at present, the remaining 700 will be offered to the public.

Latter-day Saints and Latter-day Progress.—Salt Lake City, Utah, contains 11 miles of electric tramways at work, and a further length of six miles is under construction. There are 15 electrical cars in circulation, and five others are promised.

Paterson and Cooper.—We have received from Messrs. Paterson and Cooper a copy of their new catalogue of dynamos and electric lighting apparatus. In the preface they state that they have, during the last six years, erected or supplied plant for 500 installations in all parts of the world, and that the Phœnix dynamo manufactured by the firm has been supplied in large numbers for ship lighting.

Gülcher (New) Electric Light Company.—Mr. Binswanger, who when the present company was formed was elected a director to represent the interests of such creditors of the old company as exchanged their claims for shares in the new company, has now resigned, considering that, now that the remaining share capital has been issued, his task is at an end

SS. "Relay."—The Central and South American Telegraph Company's new ship, the *Relay*, arrived off Silvertown works on the morning of March 18th. She is taking on board cable, buoys, grappling rope, and the necessary cable stores. She is expected to sail for the West Coast of South America in about 10 days.

The Royal Society.—On Thursday, March 20th, at 4.30 p.m., the Bakerian Lecture, on "The Discharge of Electricity through Gases," will be delivered by Prof. A. Schuster, F.R.S.

French Exhibition.—A French Exhibition is to be held at West Brompton this year, from May to October, inclusive. Class IV. is devoted to metallurgy, machinery, electricity, railways, &c.

Universal Telephone Company.—The Universal Telephone Company (Messrs. P. P. Kipping and Company) have issued a circular stating that they have arranged to take over the business of telephone contractors lately carried on by The Atlas Electrical Manufacturing Supply Company (Daniel Judson and Son, Limited, proprietors), and have arranged to carry out all the existing agreements relating to maintenance of telephones, way-leaves, easements, and all contracts entered into by them.

Bernstein's Electricitatswerke K.G.—Mr. Alexander Bernstein in a communication from Hamburg informs us that he has sold his business and works to a private company, under the title of "Bernstein's Electricitätswerke Kommandit-Gesellschaft," for the purpose of enabling him to meet the increased demand for his specialities.

Electricity in the City.—A report presented by the Streets Committee to the Commission of Sewers relative to the proposed contracts with the Brush Electrical Engineering Company and the Laing, Wharton and Down Syndicate was on Tuesday considered with closed doors.

The Proposed Central London Railway.—A meeting of the City Commission of Sewers was held at Guildhall on Tuesday, Mr. Frank Green presiding. Mr. Rose-Innes moved that the objections of the Commission to the principle of the proposed Central London Railway Bill were of a formal character, and designed to enable the Commission to deal with every point that might arise during the progress of the Bill detrimental to the rights of the Commission, and to preserve the interests of the ratepayers, and that they were not to be taken as representing the Commission as opposed to a scheme for increased facilities of transmit through the congested thoroughfares of the City. He argued that blind opposition to the line on principle was a great mistake. Mr. Judd seconded the motion, and urged that, in consideration of the congested state of the traffic in the City and the metropolis, additional railway accommodation, either overhead or underground, was a necessity. Mr. A. A. Wood, as an amendment, moved "the previous question," which Mr. Treloar seconded. On a division, after a short discussion, the amendment was carried by a small majority.

The Frankfort Commission.—The report of the Frankfort Commission on the electric lighting of that town, which comes to a close in this issue, must have interested many of our readers. The names of the signatories ought to have been a sufficient guarantee that the matter was thoroughly discussed, yet the letter from Dr. Nordmann which we publish to-day shows that the decisions arrived at are, in at least one instance, open to correction. Could not some English cities, when in such a dilemma as that in which Brighton has recently been, adopt a similar method of procedure, which if properly carried out by competent experts ought to settle all doubts?

Lecture.—A lecture on the Manchester Ship Canal was delivered by Alderman Bailey in the Memorial Hall, Manchester, on Wednesday night.

The Ha'porth.—This is the title of a new weekly paper of the light literature style which is so evidently popular nowadays. Judging from the specimen copy before us it should have a wide circulation.

The Dangers of Electric Lighting.—Mr. David Cook has been writing long articles in the *Glasgow Herald* on this topic. We trust that in our next we shall be able to touch upon the danger of allowing Mr. Cook free license to air his very extraordinary ideas concerning physical terms.

Statistics.—During 1888, 231,270,622 lbs. of copper were produced in America. The value at New York was $33,833,954.

English Companies in Spain.—The *Diario de Barcelona* announces that Messrs. Woodhouse and Rawson, of London, have entered into a contract or mutual arrangement with the Sociedad Espanola de Electricidad, of Barcelona. The English firm joins the Spanish one in the character of shareholder, and, we are told, contributes a considerable capital to the undertaking. The amalgamated firms propose, so we are informed, to establish a central station for the lighting, public and private, of the town of Barcelona.

The Cardiff Telegraphists.—The suspension on Tuesday of the local secretary of the Postal Telegraph Clerks' Association at Cardiff has excited much indignation among the telegraphists of London and the provinces. It is alleged that the suspension in question was owing to the local secretary having forwarded to the Postmaster-General a copy of a resolution passed at a recent meeting of the staff of telegraphists at Cardiff.

Lighting the Homerton Infirmary.—The project for lighting this establishment appears to be quashed—for the time being, at all events. This seems a great pity, for only a week or so ago the lighting appeared to be virtually decided on.

Electric Light Dividends.—The New Australian Electric Company has, according to the Melbourne *Daily Telegraph*, paid a 10 per cent. dividend from its first balance-sheet, and in addition carried another 12 per cent. into the next year.

NEW COMPANIES REGISTERED.

Durand Electric-Petroleum and Gas Engine and Manufacturing Company, Limited.—Capital £100,000 in £5 shares. Objects:—To take over as a going concern the business carried on at 163, Avenue Victor Hugo, Paris, by Eugene Durand, the nature of which is not stated in the memorandum of Association. Signatories (with one share each): J. D. Cahill, Cork; T. Bury Wells, 6, Pembroke Street, W.; F. Davids, 22, Davies Street, Berkeley Square; J. Russell, 175, Strand; F. Street, 16, Victory Square, S.E.; C. Furtado, 172, Oakley Square, N.W.; P. E. Pritchett, Hornsey. Registered 15th inst., with special articles of association, by Mr. H. M. Green, Havant, Hants, solicitor.

Elmore's Wire Manufacturing Company, Limited.—Capital £300,020, divided into 150,000 ordinary shares of £2 each and 10 founders' shares of £2 each. Objects:—To acquire from Elmore's Patent Copper Depositing Company, Limited, patent rights, licenses and privileges referred to in an unregistered agreement. To manufacture and deal in copper and other metals, and in all metallic alloys of the same. To carry on the business of an electric light company in all branches. Signatories (with one share each): E. Wallace Lamport, 18, Church Road, Willesden; J. A. Pledger, Springfield, Chelmsford; J. Rickard, Thurlow Park Road, West Dulwich; A. Stevens, 11, Queen Victoria Street; Arthur Smith, 28, Stamford Road, Walthamstow; R. S. Jennings, Capel Road, Forest Gate, E.; J. Shurmer, 4, Gilbert Road, Lambeth. The first directors are Sir J. H. Morris, E. J. Carson, J. Mac Farlan, J. J. Atkinson, J. Thompson Cooper, George Smith, and Wm. Elmore; qualification, 250 shares; remuneration, £200 per annum each, plus an extra £100 for the chairman, together with 5 per cent. of the net profits after payment of 20 per cent. dividend on the ordinary shares. Registered 15th inst., by Hollams, Son, Coward & Co., Mincing Lane.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Electrical Engineering Corporation, Limited.—An agreement of the 1st inst., filed 13th inst., between this company and John Grice Statter, cites by an agreement of 9th January, this company agreed to purchase the business of J. G. Statter and Co., Limited, and that as part of the 5,200 shares, of £5 each, should be allotted as fully paid. The present agreement provides for the allotment of that number of shares to the liquidator of the old company and his nominees.

An agreement of 1st inst., filed on the 14th inst., between this company and A. Sydney Gedge and Wm. Leonard Madgen, the liquidators of the United Electrical Engineering Company, Limited, cites that at meeting of the latter company, held in December last, it was decided to effect an amalgamation with J. G. Statter and Co., Limited, and that the liquidator be authorised to consent to the registration of new company under the title of the Electrical Engineering Corporation, Limited. In accordance with previous agreements, the corporation will allot to the said liquidators or their nominees 4,400 fully paid ordinary shares.

An agreement of January 9th (filed 15th inst.), provides for the purchase of the business of John Grice Statter and Co., Limited, and cites that the old company was registered on May 9th, 1887, with a nominal capital of £20,000 in £10 shares, which was subsequently increased to £30,000. Of this capital there were issued 1,516 shares. The agreement further cites that the Jablochkoff and General Electricity Co., Limited, was incorporated on January 7th, 1885, with a nominal capital of £20,000 in £100 shares, the name subsequently being changed to the United Electrical and Engineering Company. These two concerns are merged into the present corporation; 5,200 ordinary shares and 104 founder's shares to be issued as part of the purchase consideration.

An agreement of 3rd February (filed 15th March) is supplemental to the agreement of 9th January, the second clause of the same being modified as follows:—Instead of allotting to the liquidators of J. G. Statter and Company, Limited, 5,200 ordinary shares, the company may, at the option of the directors, pay to the said liquidators the sum of £26,000 in cash or in fully paid up ordinary shares, or partly in each.

National Electric Supply Company, Limited.—The statutory return of this company, made up to the 12th inst., was filed on the 14th inst. The nominal capital is £100,000 divided into 100 founders', and 19,900 ordinary shares of £5 each. 98 of the former, upon which the full amount has been called, and 490 of the latter (£1 called) have been allotted. The calls paid amount to £910, and unpaid to £70. Registered office, 12, Coleman Street.

Windsor and Eton Electric Light Company, Limited.—The annual return of this company, made up to the 13th inst., was filed on the 14th inst. The nominal capital is £30,000, divided into 5,950 ordinary shares of £5 each, and 250 founders' shares of £1 each. The shares taken up are 7 founders' shares upon which the full amount has been called, and 243 ordinary shares upon which £3 has been called. The calls paid amount to £764.

Chelsea Electricity Supply Company, Limited.—The annual return made up to the 5th inst. was filed on the 14th inst. The nominal capital is £100,500 divided into 20,000 shares of £5 each, and 500 founders' shares of £1 each; 7,460 of the former and 333 of the latter are taken up, 3,849 £5 shares and 333 £1 shares are considered as fully paid. Upon 164 shares the full amount has been called, upon 2,185 £4 has been called, and upon 1,262 £3 has been called. The calls paid amount to £13,181, and unpaid to £165.

CITY NOTES, REPORTS, MEETINGS, &c.

Exeter Electric Light Company, Limited.

AN extraordinary general meeting of the Exeter Electric Light Company, Limited, was held last week at the company's works in the New North Road. Mr. W. H. Ellis (chairman of directors) presided, and amongst those present were Lady Bouring, Dr. Woodgates, Dr. Bankort, Messrs. L. J. Kennaway, C. J. B. Sanders, G. F. Truscott, G. H. Massingham (managing director), C. T. K. Roberts (company's solicitor), and H. Michelmore (secretary). The meeting was convened for the purpose of considering, and if thought fit, to pass a resolution to the effect that the company's articles of association be altered by the insertion of the word "ten" in the first line of article 56, in substitution of the word "seven," so that the article might in future stand as follows:—"The number of directors shall be ten, or such smaller number (not less than five) as the directors may from time to time determine." In opening, the Chairman remarked that the machinery in the company's possession was now nearly all paid for, and if they had another engine and dynamo they would then be able to supply the large number of 6,000 lights instead of 3,000, as at present. The cost, however, would be about £2,000, and as the company was short of capital, he suggested the advisability of shareholders taking up more shares themselves, and also to induce their friends to purchase some. They would then be able to supply the demands they were receiving, and accordingly increase their revenue, because the expenditure in connection with the supplying of 6,000 lights when they secured the additional machinery would be very little more than the cost of supplying 3,000. The company proposed to add Dr. Woodgates and Mr. Joseph Dalke to the directorate, both of whom had consented to the proposal. He then moved the alteration of the article 56, so that it might in future stand as given above. Mr. C. J. B. Sanders seconded, and, in supporting, Mr. Massingham observed that he hoped it was only a question of time—and not a very long time—before the Town Council would see their way clear to light the streets with electricity. They were rivals, but friendly ones, of the local gas company, but, at the same time, he thought they might fairly ask and receive some of the sympathy and consideration which the Corporation had extended to the gas company for so many years. The motion was then put and carried unanimously.

Newcastle Electric Supply Company, Limited.

The Newcastle-upon-Tyne Electric Supply Company, Limited, held its first annual meeting at the company's offices, St. Nicholas' Buildings, Newcastle, on Monday, Alderman Gibson presiding.

The following is a copy of the directors' report:—The directors have to report that since they met the shareholders in May last the company has erected a substantial and commodious building in Pandon Dene, in close proximity to the Blyth and Tyne branch of the North-Eastern Railway, and in it they have placed two boilers and two engines of 200 horse-power, and two dynamos. Each set of plant is capable of providing electric current sufficient for 3,000 10-C.P. lamps, equal to 100,000 watts. It would not, however, be prudent to work without a complete unit of plant in reserve, which, therefore, only leaves one set of plant available. The company was prevented by unforeseen difficulties with regard to the Board of Trade license from commencing to lay their cables until the 11th of December last. Since that date they have laid up to the date of this report 5,400 yards of pipes, with 125 junction boxes, and drawn in 1,600 yards of cable, besides 300 yards of temporary cable on ground not yet ready for permanent work. The work of actual lighting was commenced in Grey Street, on the premises of Messrs. Reid and Sons, Messrs. Larsen and Son, and Mr. Ellenger, on the 31st January, 1890, and at the present time the company is daily supplying current for 800 10-C.P. lamps, some of which may be seen in the establishments of Messrs. Reid and Son, Larsen, Ellenger, Davidson, Crawley, T. C. Watson, T. Brown, J. Bacon, and R. J. Charleton. Contracts have been entered into equivalent to about 2,500 10-C.P. additional lamps, which will be brought into work as fast as the necessary wiring of the premises can be completed. Negotiations are pending with many persons who contemplate using the electric light, and the directors are quite convinced that there is an ample field in this city for the profitable employment of a large capital in supplying the demand already in view. The directors have to report that they have agreed with the Newcastle and District Electric Lighting Company, Limited (who have similar power to those granted to this company), for a division of the electric lighting work to be done in this city. Roughly speaking, this company takes the eastern half and the other company the western half, and an area bounded by Sandhill on the west, Broad Chare on the east, and Akenside Hill and Dog Bank on the north, is common to both companies. The main advantage of this arrangement is that it saves the useless expenditure of capital which would be involved in the laying of two sets of mains in the same streets and the consequent additional interference with the public thoroughfares. The capital of the company, £15,000, which comprises the first issue, has been fully subscribed for, of which £12,000 has been called up (including £1 per share payable on the 24th instant) and it is not intended to make any further call on these shares. This capital is calculated to provide and pay for the plant already erected, and about 3,000 yards of pipes and cables, with the necessary junction boxes. But the directors, being of opinion that the demand will overtake their present power of supply before next winter, have determined to extend the buildings and to lay down a third set of plant, viz., boiler, engine and dynamo, and to increase the total length of pipes and cables to about four miles. The directors further think that some provision of working capital should be made for in-door wiring work, which it is desirable the company should be prepared to undertake when required, and altogether they consider that the expenditure of a further sum is desirable. This will double the working power of the company, which will then be equal to a supply of current for 9,300 10-C.P. lamps, of which 6,200 will be available after allowing for one set of plant being held in reserve. The directors have made arrangement for the provision of this money. No appeal has yet been made to the general public to take shares in this undertaking, and the present view of the directors is that it is desirable, if possible, to defer making any such appeal until after the third set of engines, &c., is at work. The whole of the directors retire from office at this meeting, and offer themselves for re-election. The directors recommend that the number of directors, which is at present seven, be increased to nine, the limit fixed by the articles of association.

The report and accounts were adopted and approved. It was resolved to increase the number of directors to nine. The whole of the retiring directors were re-elected, and Col. Sheppee of the Birtley Iron Company, and Mr. James Knott, shipowner, were elected additional directors.

Elmore's Wire Manufacturing Company, Limited.

THE prospectus states that this company is formed to acquire the exclusive British licence to make all kinds of metal wires, ribbon, tape, and rod by the Elmore processes, with the sole right to grant sub-licences for the same; it is formed pursuant to the original intention of the licensing company, which was to have a separate company and capital to carry out the great amount of work the directors were certain would be offered to the wire manufacturing department. The company will have a capital of £300,020, divided into 150,000 ordinary shares of £2 each, and 10 founders' shares of £2 each. The present subscription is limited to 100,000 ordinary shares; the price of the issue is £3 per share, being at £1 per share premium. Messrs. Clark, Forde, and Taylor report on a series of experiments on Elmore's copper wire, on which a favourable opinion is expressed. The directors feel confident that a profit will be made of over £100,000 per annum, exclusive of royalties on sub-licenses. It is expected there will will be an output of 100 tons per week. The purchase money to be paid by the company to Elmore's Patent Copper Depositing Company, Limited, is £75,000, and half the amount of premiums received by any issue of shares by this company; and also the allotment of the 10 founders' shares of £2 each, altogether amounting to £125,020.

Foreign and Colonial Electrical Power Storage Company.—With a capital of £100,500 in 20,100 shares of £5 each, of which 100 are founders' shares, and the remainder ordinary shares, payable 10s. per share on application, £1 10s. on allotment, and the balance as required, in calls of not more than £1 per share, with intervals of not less than two months between successive calls. The list closed on Tuesday.

Schooling and Company, Limited.—At a meeting of the Board of Schooling and Company, Limited, held this week, it was decided that the directors recommend, at the forthcoming meeting of shareholders, a dividend of 5 per cent. for the last six months, making, with the interim distribution, 10 per cent. per annum for the past year.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending March 14th, 1890, amounted to £4,644.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 14th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,493.

West India and Panama Telegraph Company, Limited. The estimated traffic receipts for the half month ended the 15th March, are £3,502, as compared with £3,625 in the corresponding period of 1889.

ELECTRIC LIGHTING AT THE UNIVERSAL EXHIBITION OF 1889.

AT the ordinary monthly meeting of the *Societé International des Electriciens*, held February 5th, 1890, Col. Sibert presiding,

M. HIPPOLYTE FONTAINE gave an account of the labours of the *Syndicat International des Electriciens* during the Exhibition of 1889, he said:—

My remarks refer, not merely to the nature and intensity of the lighting which has been accomplished, but also, and especially, to the installations which have been made in connection with such lighting, and as regards which a previous communication which I had the honour to make, contained a much too summary description. In the first place I shall have to refer you to the organisation of the syndicate, and mention an important modification which took place in its conventions with the State.

You recollect that the syndicate was composed of twenty-six electricians from various countries, and was under the management of a statutory council of administration formed of representatives of four great Parisian firms, viz., MM. Rau, of the Compagnie Loison ; Lemonnier, of the firm of Sautter, Lemonnier et Cie. ; Fabry, of the *Société l'Eclairage Electrique*, and myself. M. de Bovet, civil and mining engineer, was Director, and M Picou, engineer-in-chief.

After a number of preliminary schemes had been laid before it and conferences held, the State gave its assent to our holding a collective exhibition of electricity at the Champs-de-Mars, in the Galerie des Machines and various other parts of the Exhibition premises. We were also authorised to make a charge of 2 francs weekly and 1 franc on Sundays for each visitor after 6 p.m., on condition that we handed over a moiety of the receipts to the administration. We undertook to defray the entire cost of the installation, amounting to some millions (francs), and the working expense. The State had nothing to pay, it had only to fill its pockets.

Every portion of the installation was taken up simultaneously under the superintendence of M. Alphand, and some of our stations were already built and were only awaiting the arrival of the electrical and mechanical plant from the factories, when the ticket scheme was sprung upon us, whereby the State, instead of charging gate-money, was to authorise the creation by the Credit Foncier of 30 millions of tickets and to receive from this establishment 21,500,000 francs in exchange for tickets issued.

When M. Christophle laid his ticket scheme before the Minister, M. Berger sent for me, explained the idea, and asked me whether the syndicate would consent to forego the receipts, to which it had a right, for a sum of 1,800,000 francs, that being the amount he estimated as sufficient to cover the syndicate's expenses. He added, "By this means the electricians will have made a brilliant exhibition without its costing them a penny and may be sure that the risk they may run can only at the very most be extremely limited."

The truth was that the State foreseeing a considerable number of visitors, thanks to the amalgamation of tickets, had ceased to care about paying several millions to electricians.

I told M. Berger that the ticket scheme would be an excellent thing for us, that our prospects of a profit would be considerably increased, but that the proposed sum appeared to me extremely moderate, regard being had to the advantages we should be foregoing ; however, for the sake of being agreeable to him, and of helping the State in the matter of the tickets, I had no doubt of my colleagues' consent to the proposal.

This consent was given two days later ; our previous convention with the State was accordingly modified after the smallest possible discussion, and without the least haggling over the new terms. Instead of being told "You shall have a moiety of the evenings' receipts," we were told "You shall have a fixed sum of 1,800,000 francs," and we agreed.

I shall not conceal the fact that the alteration considerably diminished our part in the Exhibition. From being associated with the State we became mere lighting undertakers. Our responsibilities increased ; the State, now become paymaster, was exacting ; in short, our position with regard to it was suddenly altered to our disadvantage.

Doubtless you will observe : "Why ! you were complaining that the State gave you nothing fixed, and now you complain that it allows you a considerable sum. Decidedly electricians are hard to please !"

At first sight the reflection seems justified ; but it is easy for me to reconcile the apparent contradiction, and to exonerate the electricians from the double reproach of inconsistency and greed.

The original treaty authorised us to make a collective exhibition, and contained no penal clause for delays or partial extinctions. Consequently, the members of the syndicate got ready their material with the view of profiting by the Ministerial authorisation in order to publish their lighting schemes, and without any idea of being called upon to fulfil the rigorous conditions involved in a public service as extended and complicated as it actually was. Their intention had been only to admit the evening public when they were all absolutely prepared, after having made their trials in common—rehearsals in fact.

In 1881 the electricians only opened the gates of the Palais de l'Industrie to the public, fifteen days after the inauguration of the Exhibition, and they suffered neither summonses, nor deductions, nor reproaches thereby. They had, therefore, the right to suppose that it would be the same in 1889, and to act accordingly.

However, M. Alphand thought otherwise : the opening had been irrevocably fixed for May 6th ; everything must be open, everything complete ; everything in operation at that date. Consequently, whether we liked it or not we had to light up on the very evening of the official inauguration, nor interrupt the lighting for a single instant until the 6th November, the date of the general closing. It is true that all the lighting was not entirely complete on May 6th ; neither that of the palace, nor of the gardens, nor of individual exhibitions, nor even of the Eiffel Tower.

In the main, however, the syndicate carried out its obligations ; the lighting was extremely regular, taken as a whole, and not the most trifling accident occurred through failure of light.

At the present moment I am free to confess that towards the close of April we felt considerable anxiety —were almost disheartened in fact—owing to the circumstance that the installation of its boilers by the *Société l'Eclairage Electrique* was still uncompleted ; and we felt considerable misgiving as to whether we should be able to illuminate the gardens on the day of inauguration. However, the Société, in face of the heavy responsibility that rested upon it was equal to the occasion. In *four days* it installed in the Avenue de Suffren a provisional station of 90 H.P., and laid 20 kilometres of new cable across the gardens. This station was able to supply 80 Jablochkoff candles and enabled us to wait until the Société had completed its boilers.

You are aware that we had six central stations, viz., the Gramme, the Edison, the Jablochkoff, Marcel Deprez, Ducommon, and the syndicate's own station.

The syndicate had also a supplementary station on the banks of the Seine which, however, on account of its trifling importance, I place in the category of posts for electricity.

The *Station Gramme* was situated between the *Palais des Machines* and the *Galeries des Industries Diverses ;* it occupied a space of 684 m. 9 (38 m. in length and 18 m. in width). In my opinion it was the perfection of a *temporary* installation for ensuring a public supply.

The syndicate had entrusted to the Société Gramme a section of the lighting which was of the first importance, and in connection with which failure was not to be entertained for one moment upon any consideration. I allude to the lighting of the fountains and of the principal lustres in the *Palais des Machines.* The gardens might be left in partial obscurity, and then on the *Palais des Machines* the ordinary lamps might go unlighted, the administration imposed a proportional fine upon the syndicate, and nothing more needed to be said. But should the 60 ampères-regulators fail or, above all, the fountains cease to be luminous, then all would literally be lost with the syndicate through the cessation of the fountains and the closing of the *Palais des Machines* during the evenings, and the success of the exhibition would have suffered irremediably.

The Société Gramme was moreover entrusted with the lighting of the central dome. The extinction of the light here would not have had as serious consequences as in the case of the fountains and of the main passage in the *Palais des Machines* ; still, from a decorative standpoint, the lighting of the dome was of capital importance, and it would have been extremely mortifying to have had to record failure, or even irregularity in this respect. So that the primordial

qualification of the Société was, that it must offer absolute security for its daily performance. It must, moreover, be in a position to answer for a perceptible increase in its normal production every evening at the commencement of each performance of the luminous fountains, without which the result might have been a considerable over-heating of the wires, sparks which would have been hurtful to the brushes, irregularities in the speed of the motors, or a lowering of the pressure in the steam generators.

The Société entrusted the fulfilment of these conditions, as regards the mechanical service, to Messrs. Davey, Paxman & Co., of Colchester; it demanded the installation of one horizontal engine of 350 H.P., one ditto of 250 H.P., and one ditto of 125 H.P.; all three engines being capable of furnishing a supplementary power of 25 per cent. above their normal capacity.

They were fed by a set of five boilers, similar to those used on locomotives.

The current was supplied by six dynamos, two being of 111,600 watts coupled in series, and driving direct from the 350 H.P. engine; two of 58,200 watts coupled in series and operated by the 250 H.P. engine, and two of 33,960 watts, likewise coupled in series, worked by the 125 H.P. engine.

The difference in total potential at the terminals of each group of dynamos was 240 volts (120 per dynamo).

The current of each group could, if desired, be sent to the Palais des Machines, into the interior of the dome or to beneath the fountains, so that had any one dynamo failed, the total lighting would have been diminished by so much, but a total extinction would have been avoided.

The following were the principal features presented by the dynamos :—

Designation.	Machines of		
	900 ampères.	480 ampères.	275 amps.
Total power of each dynamo in kilowatts (including excitement)	111·6	58·2	33·96
Volts available at the terminals...	120	120	120
Amps. available at the terminals...	900	480	275
No. of revolutions per minute ...	310	440	750
Exciting current in the field-magnets, in ampères	30	5	8
Resistance of the armature at 15°	0·0030	0·00676	0·0154
Resistance of the field magnets in derivation	4·00	24·00	15·00
Resistance of the field magnets in series	4·00	0·0056	15·00
No. of ampères per square millimetre of section (armature) ...	2·8	2·85	3·2
No. of ampères per square millimetre of section (field magnets).	2·0	2·0	1·9
Electric yield	94·5	94	93·5
Mechanical industrial ditto ...	89·2	88·00	88·00
Length of machine, including pulley	2950 mm.	2100	1845
Length of machine, without pulley	2465 „	1650	1560
Height	1790 „	1300	1100
Width	1230 „	1200	1785
Weight	10600 kg.	5150	2200

The dynamos were perfectly well behaved throughout.

The 350 H.P. engine was on the compound system, in American framework; speed, 65 revolutions, and was fitted with a Paxman distributary system. The piston's stroke was 1 m. 22; the cylinder's diameters were 0 m. 889 and 0 m. 558.

The 250 H.P. was on the compound system, with intermediary reservoir. Its speed was 95 revolutions per minute; the piston's stroke was 0 m. 609. The cylinder's diameters were respectively 0 m. 724 and 0 m. 470.

The 125 H.P. engine was of a similar type to the foregoing, and had a speed of 105 revolutions, a piston stroke of 0 m. 610, and cylinder diameters of 0 m. 324 and 0 m. 508.

The three engines working at a pressure of 8 kg., without condensing, behaved very well throughout. There were no stoppages, their working was regular, notwithstanding variations in the work; in a word, they performed excellent service.

The boilers were heated by small coal and dust, by means of Godillot's automatic feeders. This method offered the two-fold advantage of being very economical and of not causing smoke. Its employment presented no difficulty of any kind when the apparatus were properly arranged and ordered.

I consider the absence of smoke a great advantage, and I should like it to be made compulsory in all the electrical stations of Paris. A smokeless fuel is not difficult to obtain; the numerous steam vessels on the Seine prove that nothing is easier. The smoke which is caused by our public buildings and large warehouses is hurtful in the highest degree, and I really cannot conceive how our Municipality, which ordinarily concerns itself so much in æsthetic matters, can tolerate such a state of things. Is it waiting for Paris to become as black and as dirty as certain manufacturing towns in England before taking effectual measures against factory owners? Of all the criticisms levelled against central stations that of their being the fruitful cause of smokiness is the only one which appears to me well founded. The interest of electricians and of the city alike call upon the municipal authorities to do away with the nuisance with the least possible delay.

Apologising for having digressed into matters foreign to my subject, I now return to the Gramme station.

To sum up—to secure absolute reliability and elasticity for the production the Société had installed we require: (1) Boilers of great capacity, smoke consuming furnaces, and duplex feeder apparatus; (2) Horizontal condensing steam engines, of great simplicity, and easily accessible at all points; (3) Dynamos capable of sending a current in all directions; (4) Lamps all similarly grouped, and capable of being used with each pair of dynamos.

(*To be continued.*)

ELECTRICITY AS APPLIED TO STREET RAILWAYS.*

By FRANK J. SPRAGUE.

SCARCELY fifteen years, a period of time yet within the memory of the youngest of us, have passed since the beginning of a new era, the era of the transmission of energy for light, power, and the reproduction of speech. But that great industry, the transmission of electricity for power, with its possibilities of all kinds, is of very recent development. Six years ago there were scarcely a hundred electric motors in operation in the United States for any purpose. To-day there are no less than 15,000 motors in use, applied to not less than 200 different industries, and an industrial revolution is taking place equalling, if not surpassing, in importance that attending the introduction of the steam engine, and marvellous in the rapidity of its growth.

The modern electric railway may be said to have been born in Europe; its babyhood was in Europe; but in its youth and younger manhood it is purely American. In 1881, Dr. Siemens, of Berlin, established the pioneer railway on the Lichtenfelde line in the suburbs of Berlin, and I believe it is still running. It was followed by other roads, some commercial and others for exhibition, erected by the firm of Siemens, and by work done by other electrical engineers. The Siemens Company also established a line at Frankfort. The Drs. Hopkinson established one at Portrush, Ireland. Another was established at Blackpool. This last was a conduit system. A double metallic overhead system was established in 1888 at Vevey, Switzerland, and comparatively recently the Siemens have established a conduit system at Buda Pesth.

The first line which was established in the United States for actual commercial service was a suburban line of two miles in length, built by Mr. Daft just outside of Baltimore, in the latter part of 1885, using a central rail. Other lines were established by Mr. Vanderpoele in various parts of the country, using the single and double trolley systems, with the trolley travelling upon and carried by the wire and connected to the car by a flexible cable.

* Abstract of paper read before the Kansas City Electric Light Convention.

In all this pioneer work the system used was that of direct supply, but most of the mechanical features as well as the electrical details have now given way to other and more efficient methods of operation.

Of the more recent work three classes demand attention, one being the system of independent units operated by the storage battery, and the other two being direct systems of supply, one underground the other overhead.

There is something exceedingly attractive in the proposed application of storage batteries to the propulsion of cars. But look at it commercially. The storage battery is still a long way from being a serious competitor of the direct source of supply. The capacity of the battery, while it has been somewhat increased, remains such that it is still necessary to have about 3,500 pounds to propel an ordinary street car. This means an excessive weight. It requires frequent shifting, and its capacity as well as discharge rate are so limited that it is simply impossible to work such a battery upon grades which are at all severe. I believe it is possible with care to operate a storage battery on grades not exceeding, say, 4 per cent., and with limited speed and daily mileage at an expense about equal to that of horses, or a little less; but still at about double the expense which is necessary upon a suitably erected and properly operated overhead system.

Nowhere in the United States, that I am aware of, is there serious storage battery work being done at the present moment. Nowhere is the work done at all, equivalent to what is constantly practised on the overhead line. On that service motor cars start out at 5 or 6 o'clock in the morning, and run until midnight. Many cars make 150 or 160 miles a day, and some cars have even made 180 and 190 miles a day. Half of this for storage battery work is good duty, but it is not up to the demands which street railway managers make, and until radical improvements are made in it, the field of application will be limited.

The conduit system of direct supply has been attempted in several places, notably at Denver, Cleveland, Allegheny City and Boston, but at all the places mentioned these experiments have proved disastrous and have been abandoned save the short section at Allegheny City. In England, the Blackpool line under special conditions has been, I believe, fairly successful, and at Buda Pesth the Messrs. Siemens have a conduit system in successful operation. There, however, the drainage is very perfect, and in addition a man is detailed for given sections of the track, and is continually employed in patrolling his section and clearing it out. Assuming good sewerage, the conduit can unquestionably be made to work. It becomes then a question of cost; but for general application, especially in view of the fact that most of our cities do not have a sewerage system which can take care of the street drainage, the expense is prohibitory save on large systems under exceptionable conditions. I look forward to the time when many existing, well constructed and well drained cable conduits will become electrical conduits, and electricity will then score another victory.

The system, however, which has made such a marked advance is the single trolley overhead system with universally flexible underneath contact, and this has been the growth of the past two and a half years. I think I can fairly claim for the Sprague company the pioneer place in this development, but the commercial development on the lines it laid down has been with great energy pushed forward, principally by both it and the Thomson-Houston company. The first work done by the Sprague company, other than experimental work on the elevated railroads, was made but a short distance from this city. A single car was started in 1887 on the Union Passenger Railway Company's line in St. Joseph, with a small 7½ horse-power motor, single geared, and adapted to run at a very high speed on a suburban extension. It is a matter of interest that that line has seen nearly every change made in the system. Its lines have been extended twice, and it has both the old style motors and the more modern equipments. But all the work done on that line in 1887 was, it may be said, purely experimental; and it was not until the 2nd of February, 1888, that the Richmond road was officially opened to the public. I speak of this road not so much because of my personal interest in it, but because it marked an era in the development of electric railways. A radical departure was made from the work which had been done prior to that time, not only in the amount and extent of the system equipped and the number of the machines operated, but also in the disposition and control of the machines, the system of overhead wiring, and the method of getting the current from the wire. The characteristics of that line are now pretty well known. It was a road of about 12 miles in length, with 30 curves, some of them of exceedingly short radius, with grades running as high as 10 per cent., and with a road bed utterly unfit for the traffic which it had to support. The equipment was for 40 cars, requiring 80 machines, and was to be operated from one central station. When first proposed the attempt was looked upon with a good deal of ridicule, not only by street railway men but by electricians themselves. The street railway men thought that the ordinary condition of street car service would make it impossible for a self-propeller car to ascend a grade exceeding 5 or 6 per cent., and as for attempting a 10 per cent. grade, that was out of the bounds of reason. As regards the electrical problems, the motors instead of being placed on the car body flexibly, connected by chain gearing or belts to the axles, were placed underneath the car, and flexibly and concentrically geared to the axles. They were uncovered and exposed to the mud and moisture, and to all the loose combinations which might accumulate in the street. They were built to run on a 400-volt grounded circuit, and to run in either direction with fixed brushes. Insanity was a mild term to designate the mental condition of one who made these proposals. The motor man was confined to his ordinary platform, and the regulating devices there situated. A wire of one-fifth of an inch in diameter was extended over the track, and supplied at intervals of its length by a wire carried alongside the street where the strain upon the poles was least, and this main conductor was supplied at three or four central points by feeders, which came from the central station. The current, moreover, was taken from this wire, not by a travelling carriage upon the wire, flexibly connected with the car, but by an arm reaching upward and pressing underneath the wire. This contact arm, which is now technically known as the trolley pole, was placed in the centre of the car and had a universal movement, resisting up and down movement sufficiently to make a good contact with the wire, but at the same time free to follow all vertical deflections. In addition it had a lateral movement of considerable reach, offering little opposition to any side deflections by the wire itself.

Well, Richmond has passed into history. It has had its vicissitudes—it has had its victory as well. But it remains with all its crudities, and with all the accidents which have marked its career, as the one great step in advance, whose features, in the main, have been followed in almost all the recent electric railways. Machines have been made larger, they have been made mechanically and electrically more perfect. Changes of detail have been frequent, but most of the characteristic features there outlined, mark to-day nearly every electrical railway which is either in operation, in process of construction, or under contract.

Taking our work alone, and that of 1887 as a basis, in 1888 it was trebled. The work of 1888 was quintupled in 1889. As to what it will be in 1890 I will not hazard a guess. Two years ago it was in an experimental age, and it was difficult to get a dollar for investment; to-day it demands the best thought and the most active energies of two great corporations and a number of smaller ones. The contracts for electrical equipments involve larger amounts than almost any other electrical enterprise. The business done in this year will probably be not less than $6,000,000. Every street railway in the United States is watching with eager eyes the developments of the rival electrical interests. The advocates of the cable system are on the defensive. The advocates of the electric system are reliant and aggresive. Its flexibility, the ease with which it is extended, its adaptability to various conditions of service, its freedom from a long continued breakdown, the marvellous advances which have been made in perfecting its apparatus, all insure its supremacy.

As illustrating the progress of electric railways, I may state that there are about 130 towns in the United States with one or more electric railways in operation, construction or under contract, and that these roads comprise about 1,500 miles of track, equipped with about 1,700 motor cars, requiring 3,000 motors of an aggregate capacity of 45,000 horse-power, and steam and electrical generating about 100,000 miles per day, and within three months the mileage will be doubled.

We still hear occasional discordant cries about the possibility of breakdowns, the cost of operation, the danger of the current, or the unsightliness of overhead wires.

This latter question is rather æsthetical than practical, for as now erected, the railway lines are among the most costly, and with care can, in view of the service rendered, be made very unobtrusive.

As regards danger, the electric car is the safest possible vehicle, because of the remarkable facility of control, and as to the objections to the overhead line on the score of danger which have been raised, sometimes by the authorities, and which have been cited by the telephone interests, they are, we may safely say, imaginary rather than real. Some two years and a half ago I settled upon 400 volts as a fairly satisfactory standard of potential for which the motor for street railway service should be built, allowing about 10 per cent. drop in the distribution on the line, making the potential in the station about 440 to 445 volts. In some cases, where dealing with heavy work on extended lines and small conductors, we have raised the potential at the motors to about 450 volts, making no change whatever in the machine, and have run the central station at 480 to 500 volts. There are in the United States about 80 electric railways in operation. Almost every employé of the contracting companies, and a great many employés of the railway companies themselves, including not only the linemen, and those whose business it is to work upon the electrical equipment, but also the conductors and drivers, have received shocks from these lines of greater or less duration, and under almost every possible condition. Yet, in no instance which ever came under my observation, or of which we have any reliable record, has serious injury resulted from the shock of the current itself. When we consider that these shocks have occurred to persons of all ages, and of all physical conditions, and for varying periods, the experience seems to be quite ample to warrant the assertion that as ordinarily constructed, a constant potential circuit of 500 volts is not dangerous to human life, and we can dismiss that question.

Reviewing the work of the past two years, that which was promised for electricity has been in the main entirely fulfilled. It has proved itself capable of doing the most extraordinary work under the most unfavourable conditions. Grades of 12½ per cent. and more recently of 14 per cent. have been ascended with loaded cars. Grades three miles long, varying from 4 to 8 per cent., have been ascended by a motor car pulling a tow car. It has done this work where it would have been impossible to have done it by horses. It has enabled the running speed of cars to be increased even in crowded cities 50 per cent.;

and on suburban routes speeds of 20 miles or more have been made. Experimental runs of 30 miles an hour on the ordinary street car with the narrow flange wheel have been attained; and on special experiments a speed of nearly 150 miles an hour has been attained for a short distance. The electric car has shown that it can run faster on both up and down grades; that it can be gotten under way and stopped more quickly than a horse car; that with any given number of cars the mileage has been increased and at the same time intervals made with a less number of cars. Many cars have made from 180 to 190 miles in one day. Horse space having been saved, the equipments occupy a third less space, and this fact, coupled with the ability to back when necessary, and again quickly gain headway, has enabled an electric railway car in crowded and narrow streets to work its passage where a horse car would be at a dead standstill. Not only has the possibility of running down grade faster been established, but that possibility with a high degree of safety, because in the event of losing control of a car by the brakes, the instant reversal of the motor will bring the car to a standstill. This has frequently been the experience, and in one case, which was recently reported to us, the inspector stated that a car was going nearly 35 miles an hour on the down grade before the driver attempted to reverse his machine; but when he did reverse it, he brought his car to a standstill with the loss of only one gear. Making due allowance for the possible excitement of the inspector, I think the car was moving at least 25 miles an hour when the reversal took place.

The riding of an electric car is unquestionably easier than on the majority of cable or horse cars, starting and stopping more easily and being in a very large measure free from oscillation. It is scarcely necessary to say that the cars are cleaner, that they are brilliantly lighted, and that it would be possible even to heat them by electricity. The sanitary conditions are entirely altered, and the health and comfort of the people conserved by doing away with stables with all their unsavoury characteristic and resultant injury to the value of adjacent real estate. Branch lines of every possible combination of grade, curve and ill-conditioned street, which have so often proved prohibitory to any other system of propulsion, have been operated by the electric system. Distances up to six miles or more away from a single station have been operated without difficulty, and large numbers of cars from one station. It can very properly be said that there have been many breakdowns; that machines have depreciated; that there have been exasperating troubles. True, these thing have happened; and in case of defective workmanship and of careless inspection or management, they will happen again, no matter what system of propulsion is adopted. The accidents which can happen to a motor come within a very limited category, and the liability of a motor to these accidents is being very rapidly reduced to a minimum, till it is becoming to-day the most perfect piece of machinery, capable of the longest continued use, of a large amount of abuse. The very accidents which have happened, as simple as the causes are—and I may say here that nine-tenths of electrical troubles are due to mechanical defects—and the very makeshifts which have been temporarily resorted to to overcome the troubles and keep the lines in operation, are the best evidence of the flexibility of the system and the perfection to which it will arrive. No other machine in existence has, in so short a period of development, been brought to such a degree of perfection, is capable of such varied application, and can be so quickly and easily understood.

The cost of operation has proved entirely satisfactory, and my early claim has been substantiated. In a paper read before the American Institute of Electrical Engineers in August, 1888, and also in some earlier communications, I made an estimate as to the expense of operating a thirty-car road, dividing these operating expenses under two heads; (1) those belonging to the central station; and (2) what may be called the road operating expenses; the sum of the two constituting the total cost of motive power. In making this estimate I used extreme care, and while preserving its accuracy, made every reasonable allowance that I thought necessary. The conclusion at which I arrived in the estimate under the conditions there given was that the total cost of motive power per car mile should not exceed 4 3–10c. each; and this included everything except executive and salary expenses, taxes and insurance, and other matter not connected with motive power. I also stated that this was about 40 per cent. of the cost of operating by horses for the same number of cars and under the same conditions. My estimate was then considered altogether too liberal in favour of electricity. Without going into details I may state that the most reliable possible records of roads, under every possible condition of service, bear out the claims that I then made as to the economical operation by electricity. I have the records of only a portion of the roads which we have equipped. Some roads see fit to make public these records; others, and with a good show of reason, do not care to do so because of the feeling that municipal bodies in considering the granting of franchises will not look at the increased cost of investment, but, ignoring the manifold advantages to be gained by the introduction of electricity, for the public as well as for the company, are inclined to make unreasonable demands in the way of the reduction of fares, or require unnecessary and unprofitable extensions of lines. They forget that the reduction of one cent. in a fare means a cut of 20 per cent. in the receipts of the company, and that a very remarkable saving of expenses must be made in order to meet this reduction of revenue, especially where there is an increased equipment on which interest must be earned. But suffice it to say that careful investigation will convince any candid man that the economic claim has been entirely supported, and the best evidence of it is in the rapid adoption of this method of propulsion.

A few remarks may be in place relating to the interferences with other established interests which this new application of electricity has developed. Such conflicts, as electricity is applied to different industries, necessarily arise and result from the claims made by two or three enterprises to the same area of occupancy, whether of air or earth. There have been, long before electric railways became at all common, conflicts of a more or less limited nature between the electric lighting and telephone interests. In the early days of electric lighting, and more particularly in that branch known as constant potential distribution, an attempt was made to use the earth for one-half of the circuit, precisely as was done and has been done for years in telegraphy. Practical experience, however, demonstrated that this was a mistake where incandescent lights were concerned, and it is manifestly a mistake where arc lights and high potentials are used. The objections on the constant potential incandescent circuit were pertinent because of the liability of fire in the buildings where the ground circuit was used; and the element of personal danger very quickly put an end to an attempt to use a ground circuit for an arc light system.

The same cautionary reasons applicable to these two classes of industries do not, however, apply to overhead electric railway systems. The electric railway circuit is purely an external circuit. Its derivations are through the cars which it supplies. It is led into no dwelling; its fixtures are not within the ordinary reach of any being. It is carried in the open air, in full view, in the most direct possible lines, and with only such supports as are necessary to make its construction safe and to keep it in alignment. The whole construction of an overhead electrical system is materially simplified, and, in my opinion, made, mechanically as well as electrically, far safer by the adoption of a single wire, using the rails as a return circuit. The practical proof of the wisdom of this decision is the fact that about 90 per cent. of all the electric railways, either in operation, construction or under contract in the United States, use only the single wire underneath contact. It scarcely seems necessary at this stage to go into the defence of this system. Its simplicity, the lightness of construction, the symmetry of outline, the size and strength of the poles, the fewness of the supports, the simplicity of all curve work, turnouts, crossings and sidings, and especially of all switch work and switch operations, are so manifest that elaboration of these features is unnecessary.

So much for street car practice; and looking forward we naturally ask what will be the future of the application of this remarkable agent? Already we have gone from one car units to trains of 2, 3, and even 4 cars in the street, and 40 cars have been operated from a single station. The next step will be the operation of some of the cable roads; then systems like the underground railway of London, the elevated railways of New York, the Brooklyn Bridge system, and then suburban lines will be operated. But is this the limit?

I have been frequently asked whether, in my opinion, electricity will ever be used on trunk lines for through passenger or freight traffic? My answer is, probably not, according to present notion of trunk line transportation, and not by present methods of train dispatching. But in these qualifications I admit my hope and expectation of rapid through transit under certain conditions. Let us for a moment consider a few facts.

Railroad managers are constantly meeting with a demand for more rapid and luxurious methods of transit, and every effort which executive ability and financial expenditure within reason can devise, is made to meet this demand. I think I can safely say that as steam railways are operated, a maximum speed of 90 miles per hour, and a running speed of 60 to 70, is all that can be hoped for in steam railway travel under the best conditions which can be provided. The limitations are too many. The maximum speed made by a locomotive to-day is but little more than was made 20 years ago. True, engines are larger and more powerful, but the increased weight of trains has made this necessary. To get pulling power there is a limit to the size of the drivers, and whatever their size there is a limit to the economical rate of piston speed and to the number of revolutions per minute. As the size of the driver increases the centre of gravity of the engine is raised. As the steam demands become greater, the difficulty of taking water and firing grows more pronounced. Even now it requires the best work of a fireman when his engine is pulling a heavy load to prevent the engine "dying" on the road, or at least falling far short of its duty. The increase of running speed has been obtained principally by cutting down grades, straightening curves, filling up ravines, replacing wooden structures by permanent way of iron or stone, the use of heavier rails, safer switches, improved methods of signalling, the interlocking of switch and signal system, road crossing gates, the abolishing of grade crossings; in short, by improvements in detail and management which permit a higher safe speed over a more extended section of road because of greater intrinsic safety, and of the greater degree of confidence inspired in the engine driver, rather than by marked advance in the speed capacity, which should not be confounded with the pulling capacity of the engine *per se*.

With respect to the electric motors the question is not now, can a motor of sufficient capacity be built, or efficiently and positively controlled, but rather how can the electricity be produced and supplied to the motor and at what potential can we work. We all hope to see the time when electricity can be produced economically from coal without the intervention of engines or dynamos; and

it may be that something akin to the present steam practice will be common; but I think that even then it will be quite likely that a central station method of distribution will be the more advantageous. On the other hand, there are those who hope to see the storage battery so reduced in weight and improved in other particulars as to warrant its use in a large way in locomotives. For myself, I prefer to consider the possibilities of another method, the amplification and development to its full capacity of present street railway practice, and for that purpose I will briefly consider a suppositious case, namely, an express between New York, or rather, Jersey City and Philadelphia. But before considering this problem, let me point out a feature or two about steam roads. When first laid through a new country they usually consist of a single track which must do the manifold duty of providing for through and local freights, and local and express passenger traffic in both directions, with what success those who are called upon to travel in new countries are well acquainted. The route of such a road is determined mainly with the idea of getting from one place to another by a more or less direct line, but especially by one which shall not require too costly construction. Once determined, new towns spring up along the line of the road, and old towns grow until the demands of traffic make a double track necessary, and as civilisation grows apace the freight traffic demands a track by itselt and four tracks constitute the equipment. So, following the development of the road, we will find that in time the express and local passenger trains may require individual tracks, and a six-road track will be a necessity. But it must be borne in mind that the express is not intended to cater to local travel, but its route is subordinated both in the matter of curves, grades and crossings to the requirements of the early construction. The highest demands of such a service would require that, independently of the local travel, a through express track should be constructed by the most direct route possible between the principal localities, and every effort made to reduce the curvature and grades as much as possible. No matter how much it costs to build such a road, when the traffic is sufficiently large, it will pay to do it.

Suppose such a road to be an electrical one, and the method of supply to be from one or more central stations, the current being taken by a universally flexible underneath contact from a rod carried above the car, and the return circuit made by means of the rails. This method, using of course a wire instead of a rod, having been almost universally adopted wherever street cars are propelled by electricity, its characteristics are well known. What the structure of the road bed would be need not here concern us. We might use the standard T rail and road bed, avoiding as much as possible curves, grades and grade crossing, and the overhead rod can be used simply for supplying the current; or some form of a double or single track road slightly raised above the ordinary level, and with the upper rod forming a steadying and centering cord as well as a current supplyer may be used. These are mechanical questions with which we need not concern ourselves at present. What does concern us, however, as electrical engineers is, whether the cost of copper, the potential required, the losses on the line and the number of stations are such as would be prohibitory.

As regards the potential, other things being satisfactory, whatever pressure is demanded in the interest of economical and effective service will be used, and means will be found, consisting mainly in cars of construction, which will make its use for the purposes, and as intended, safe and proper. We have in these matters to face the same questions that we have in the matter of steam pressure, or of railway speed. To accomplish the larger engineering feats necessary to meet the demands of economy and commerce, we will be governed more by belief in our power to fully subordinate a good servant to our will than by our fears of its vagaries when allowed to become a master.

From 8 a.m. to 9 p.m., a period of 13 hours, twenty-one regular trains leave the Jersey City station of the Pennsylvania road to run through to Philadelphia, twelve of these make but one or two stops. The balance make more or less stops according to the running schedule. In addition to these there are a number of local trains serving way stations. Taking the through trains only, and allowing an average of, say, five cars to a train, there are in the 13 hours about 105 through cars despatched from Jersey City, or at the rate of one car every 7½ minutes, and of the through trains not making over one or two stops there would be one every 13 minutes. We will suppose an additional express track has been built, leaving the distance about what it is now, say, 90 miles, but that the grades have been eased and the worst curves rectified. For the practical purposes of this paper, I will consider that the road is level, that the cars are to be despatched in 2-car units on a perfect block system, and to run through to Philadelphia with not more than one stop, at fixed intervals, and at a high average rate of speed, say, 60 miles per hour. In the systems that I would propose, practically that with which I experimented some years ago, slight grades would make little difference in the general result, especially if the grade percentage, if expressed as a whole number, did not exceed the quotient of the traction in pounds per ton divided by 20; because when $c = \frac{t}{20}$ where t = traction in pounds per net ton, and c = grade percentage expressed as a whole number, the work of traction and of lifting are equal. For example, suppose $t = 10$ pounds and $c = \frac{1}{2}$ per cent., and that we had on a double track one unit coming down the grade and the other ascending it, both at the same speed. Then gravity would be supplying just enough power to propel the car on the down grade at a fixed speed, and enough power to supply the lifting and traction work of the other car would have to be supplied, which would be just the amount required to propel both cars on a dead level.

Suppose the grade to exceed the ratio expressed above, then the car on the down grade would have an excess of falling energy, and this could be used in accelerating the speed of the car, or on the brakes, or it could be used by a process of reconversion for the purpose of supplying at short range part of the extra energy required by the ascending train. Just how this can be done is pretty fairly understood by electricians, but I will touch upon it again, because it is a feature of vital importance in determining the matter of motor control in a large system such as we are now considering, and because it illustrates one of the most beautiful features of this method of converting energy. No matter whether a machine be used for a motor or a dynamo, whether to convert mechanical energy into electricity or the reverse, an armature develops an electric pressure or potential which is dependent upon its speed and the effective strength of the magnetic field in which it is used. If this field is in shunt relation to the armature and in connection with the track circuit, we have by any of the well-known methods a means for independently varying the strength of that field. When such a machine is geared to a car, it can either drive the car, acting as a motor, or be driven as a dynamo, and in connection with any other similarly connected motor, or the central station generators, will form an electrical couple, either of which may be driven by, or drive the apparatus to which it is connected. If the couple thus established is between the motor and the central station dynamo, we have at one end a machine driven by a constant speed engine and generating an approximately constant electromotive force, and at the other end a machine with greatly varying speed and with facility for increasing or diminishing the electromotive force which it generates. The result is an electrical differential which will establish a current between the two in one direction or the other, according as the pressure developed by the motor is lower or greater than that developed at the generating station. If the pressures are equal no current will pass. If the couple consists of two motors thus connected, then we have two apparatuses each of which is generating a variable electromotive force, and there will be a current between these or not, according to their relative electrical pressures. A large system is tied together in the most intimate manner possible. The tracks are cross-connected, the overhead conductors cross-connected, and you would have, in effect, what would correspond to two large planes before which was moving at varying speeds a number of independent units, these two planes kept at a fairly constant potential by means of the generating station. All motors starting running on a level, or ascending a grade, would be requiring currents. All motors running on a down grade with just that velocity which the force of gravity would give them would require no current; and motors running on down grades of greater percentage than is required to give them power for traction, or motors slowing down, would be generating currents to aid in the general supply. No other system of distribution can by any possibility have this very remarkable interchange of energy. When running at a particular speed a slight movement of a regulating handle would make the motor receive from or give to the line currents in any desired quantity. The braking power of a motor thus acting as a generator is very powerful and the most perfect imaginable, because, unlike the ordinary methods, the brake does not operate if the wheels stand still, the very essential of the braking operation requiring the wheels to turn. It is a well-known fact that the most effective brakework is when the wheels do not skid upon the track, but when they are turning under the pressure of the brake; and contrary to the ordinary braking practice, the energy of the electric train, instead of being thrown away in the form of heat and using up our wheels and brakeshoes, can be made useful in the propulsion of other trains. I have tried this method of braking with such a degree of refinement that a heavily loaded car would creep on a down grade at a pace so slow that an egg could be put under the wheels and cracked and removed before the wheel would pass over it.

(To be concluded.)

NEW PATENTS—1890.

3335. "An improvement in holders for incandescent electric lamps." A. SCHIRNER. Dated March 3.

3373. "Improvements connected with the charging of electrical accumulators or secondary batteries." M. SAPPEY. Dated March 3.

3374. "Improvements in electric accumulators or secondary batteries." G. E. B. PRITCHETT. Dated March 3.

3419. "Method of and apparatus for producing and utilising pulsating electric currents in closed circuits." C. J. VAN DEPOLE. Dated March 4. *(Complete.)*

3455. "Improvements in and relating to electric secondary batteries or accumulators." H. H. LAKE. (Communicated by T. Ewing, United States.) Dated March 4. *(Complete.)*

3472. "Improvements in apparatus or appliances for operating electrically devices for informing passengers in railway carriages as to the names of stations on the line, or for conveying to them other information." J. W. LITTLE. Dated March 4.

3484. "Improved electrical secondary clockwork." E. SCHWEIZER. Dated March 4.

3509. "A portable hot air, steam, and electrical bath, with arrangement for inhaling and otherwise employing vapours, plain or medicated." C. A. SAHLSTROM. Dated March 5.

3523. "Improvements in armatures for dynamo-electric machines." J. NEBEL. Dated March 5.

3534. "A new or improved device for extending the circuit of incandescent lamps." L. W. DE GRAVE. Dated March 5.

3544. "Improvements in and relating to electric telegraphy." F. J. PATTEN. Doted March 5. (*Complete.*)

3574. "Distributing electricity." H. R. Low and G. E. B. PRITCHETT. Dated March 6.

3625. "To provide a safer and cheaper insulator that is not liable to be broken and a more ready and safer means for securing the telegraph or telephone wire to the insulator." J. S. SCALES. Dated March 7.

3654. "Improvements in apparatus or means for supplying, distributing, controlling, and metering electric currents." H. EDMUNDS. Dated March 7.

3658. "Improved electrical signal clock." J. STEINHEUER. Dated March 7. (*Complete.*)

3660. "Improvements in apparatus for connecting and disconnecting electric circuits." S. B. MCCLELLAN. Dated March 7.

3663. "Improvements in means or apparatus for metering electric currents, applicable also for indicating or recording the electrical condition or charge of secondary batteries and the like." H. EDMUNDS. Dated March 7.

3717. "An improved electrolytic solution for galvanic batteries." L. WEIGERT. Dated March 8.

3732. "Improvements in electro-locomotives." J. HOPKINSON. Dated March 8.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1889.

915. "Improvements in electric switches." S. ZIANI DE FERRANTI. Dated January 17. 8d. The object of this invention is to construct a switch of comparatively small dimensions, for passing currents of very high tension to or from either one or other of two pairs of conductors from or to a third pair. 3 claims.

1673. "Improvements in the construction of secondary batteries." G. PHILIPPART. Dated January 30. 8d. Claims:—1. Electrodes for secondary batteries, consisting of a support of lead, or lead alloy, mechanically compressed, or cast under pressure, and a fabric impregnated with active material adhering thereto, as described. 2. The application to electrodes for secondary batteries, of a neutral substance, such as perforated celluloid, for the purpose of causing additional adhesion between the lead support and the fabric impregnated with active material. 3. The construction and arrangement of electrodes for secondary batteries, substantially as described and shown in the drawing.

1823. "Improvements in telephonic apparatus." A. COLEMAN and H. F. JACKSON. Dated February 1. 8d. Consists in carrying a pole-piece, or extension, back from one pole of the usual magnetised core to near the other pole thereof, and pivoting to the outer end of the pole-piece an armature in position to be drawn towards the last-mentioned pole of the core when a current, such as is produced in signalling by a generator or battery as ordinarily employed for the purpose in or in connection with telephone instruments, is passed through the translator. The armature is provided with a suitable catch-arm, or other appliance, which releases an indicator shutter or analogous contrivance as it is itself operated by the armature. 7 claims.

2299. "Improvements in apparatus for measuring electric currents." L. A. W. DESRUELLES and R. F. O. CHAUVIN. Dated February 8. 6d. Claims:—1. A galvanometric apparatus for augmenting the extent of deviation of the parts employed in the measurement of electric currents, and comprising a thin metallic volute cut and mounted as described with reference to the drawing. 2. In a galvanometric apparatus the combination of a coil with a volute enclosed in the said coil, and in which can turn a metallic plate mounted upon a vertical axis with a spring, as and for the purpose specified.

2413. "Improvements in printing telegraphs." J. E. WRIGHT and J. MOORE. Dated February 11. 6d. Claims:—1. The construction of the type wheel shafts of column printing telegraphs with two or more longitudinal V or knife edge projections or grooves for corresponding grooves or projections on the type wheel to bear upon to reduce friction and peripheral shake during the operation of printing. 2. The combination of the type wheel shaft having longitudinal V or knife edge projections or grooves, the type wheel with corresponding grooves or projections, the carriage sliding upon a bar similarly formed with projections or grooves and the arm from the carriage entering a groove cut around the circumference of the type wheel.

3130. "Improvements in or connected with gear wheels and bearings for magneto-electric call-bell apparatus for telephonic instruments, applicable also to other mechanism." H. FRASER. Dated February 21. 6d. The inventor makes one or both of the surfaces which move in contact with the other or with each other of raw hide or skin, or hide prepared in an analogous manner. 1 claim.

11615. "Improvements in conduits and rails for electrical and other railways." F. H. REED and G. N. MCKIBBIN. Dated July 20. 8d. In carrying out the present improvements it is preferred to lay on the cross ties, under one of the track rails, a continuous conduit constructed in two sections separated by a longitudinal division. On the top or crown of each of the halves or sections of the conduit is mounted one of the sections of a longitudinally-divided track rail. According to this construction there is an open slot or passage leading from the crown of the rail down into the conduit, and extending along the entire length of the track. In the conduit are arranged two conductors for forming the electrical circuit; electrical communication between them and the motor on the car being established and maintained by means of two conductors carried by the car and extending into the conduit. The conductors on the car rub or roll against the conductors in the conduit. 7 claims.

15489. "Improvements in electricity meters." F. TEAGUE. Dated October 2. 11d. Relates to the measurement of electricity consumed in, or passing through, a working circuit by means of a small motor, which is actuated either by the main current that is desired to measure or by a shunt current of a known proportion to, and derived from, the said main current. The current measured is indicated in desired units by one or more index fingers travelling over suitably marked dials. 6 claims.

15820. "Improvements in frames for supporting the plates or elements of a secondary or storage battery." W. F. SMITH. Dated October 8. 8d. Consists in providing a plate composed of a series of small plates with a frame having a vertical lug and with an extension or auxiliary loops cast with or secured to the main portion of the surrounding frame of the series of plates for forming a connection by means of a wire or wires with a dynamo as well as with the lugs of the plates, thereby enabling the requisite number of plates to be readily connected or coupled together and with a dynamo for obtaining a good contact for the passage of an electric current for reducing said plates to a metallic state to form the elements of a secondary or storage battery. 3 claims.

16564. "Improvements in apparatus for winding clocks by electricity." H. H. LAKE. (Communicated from abroad by F. E. Morgan, of America.) Dated October 19. 8d. Consists in combining with the movement of a clock, a spring drum arranged upon one of the arbors, a contact revolving with one of the arbors of the clock movement, a stationary contact insulated from the movement, but in the path of the said revolving contact, and adapted to engage the said revolving contact during a pre-determined portion of each revolution of said revolving contact, a magnet in circuit with said contacts, a secondary stationary contact, and a corresponding movable contact, the said last-mentioned contacts being in the same circuit as the said first-mentioned contacts, the armature lever of the said magnet in connection with a pawl adapted to engage the said drum in one direction of movement of said armature lever, and so as to impart winding rotation to said drum, but escape therefrom on the return movement of said armature lever, the said armature lever also in connection with the said second movable contact, and whereby in said winding movement the said second movable contact is withdrawn from its stationary contact to break the circuit at that point while the circuit is closed at the first mentioned contact. 3 claims.

17221. "Improvements in electric telephone apparatus." H. L. TODD, W. F. MELBOURNE, J. THOMPSON and R. E. M. MOSTYN. Dated October 30. 8d. According to this invention there are employed two or more separate coils of insulated wire in conjunction with the diaphragm of the transmitter or of the receiver or both, and there is also an improved arrangement of switch cut out and push button by which the bells and instruments are cut out of or put into circuit as desired. In the transmitter the diaphragm is secured centrally so as to leave the periphery free to vibrate, and behind the said diaphragm are the aforesaid coils of insulated wire, the opposite ends of the wires of the said coils being both or all connected to the battery and the line respectively. 7 claims.

CORRESPONDENCE.

Alternating v. Continuous Current Motors.

With regard to the most interesting publication of the investigations carried on by the committee of experts lately assembled by the town of Frankfort-on-the-Main to decide on the best system to be adopted for the erection of a central station in this town, I beg to be permitted to offer a few remarks, since I had the

advantage of being an eye-witness at the execution of the experiments, the results of which are published in the preceding issues of your esteemed Journal.

Without doubt the results of the experiments would have been less occult, especially for the comprehension of non-professionals, if the important experiments had been better separated from the non-important.

For instance, the trial of the motor with regard to its behaviour when suddenly released of its load hardly deserves the same amount of interest as when suddenly loaded. As far as I am aware nobody ever has asserted that a synchronous motor would show any kind of disturbance when suddenly released, because there seems to be no reason whatever for such a disturbance. The opinion of the committee seems to a certain extent open to criticism, when they say :—

"In the transformers worked by an alternating current by means of proper insulation, and of a sufficient distance between the secondary coils and the other parts of the transformer, the dangers for the consumer may be reduced to such an insignificant degree that they do not require practical consideration."

Since the danger of introduction of the high tension into the distributing mains will be a result of the transformers becoming damaged, the comparatively high amount of 6 per cent. claimed by Messrs. Ganz and Co. for the keeping of their transformers gives rise to doubt whether the danger of transformers being damaged is in fact so small.

But, in the first place, the passage treating of the overloading and sudden loading of the alternating current motors seems to me to call for comment.

Respecting this question we learn that the 25 H.P. motor can bear an overloading of 60 per cent. over its normal yield.

Since in these experiments a continuous current motor is to be compared with an alternating current motor, naturally the standard by which the normal load is fixed ought to be the same for both kinds of motors. Now, in the ordinary use of the term, when speaking of continuous current machines, the normal load will be fixed at the same figure, whether the machine be used as a generator or as a motor, with an allowance for the rate of efficiency of the said machine. That is, if a machine which has an efficiency of 87 per cent., yields 30,000 watts as a generator, and consumes $\frac{30{,}000}{736.\ 0{\cdot}87} = 47$ H.P., it will consume $\frac{30{,}000}{0{\cdot}87}$ watts and yield $\frac{30{,}000}{736.\ 0{\cdot}87} \cdot 0{\cdot}87 = 42$ H.P., when running as a motor.

Now, Messrs. Ganz & Co.'s motor is stated to have been that firm's type A 3, No. 1,081, and, according to a price list of that firm which I have before me, an A 3 machine yields 30,000 watts as a generator. In order to get at a fair comparison between the output of an alternating current motor and a continuous current motor we must therefore not call the machine experimented upon a 25 H.P. motor, as the committee does according to the statements of Messrs. Ganz & Co., but at least a 42 H.P. motor.

Insert this figure, and the behaviour of the motor under trial shows in a very different light. We find that only when the load is put on quite slowly can the motor be made to yield something like its normal load without coming to a standstill.

As soon as this limit is transgressed the motor stops. But the normal output cannot even be approached without stopping the motor when the load is put on suddenly, for we learn that the motor stopped when loaded with 26 H.P., *i.e.*, the motor suffers a sudden throwing on of its load only up to 62 per cent. of its normal output.

By this way of putting the results obtained, which is doubtless correct for a comparison between alternating and continuous current motors; of course the conclusions drawn from these results become greatly modified, and especially so with regard to those cases in which the load varies considerably—as, for instance, in tramcars.

Of course the question as to the limit to which a motor may be overloaded, will in the end be a question of price and of weight, because in that system, which allows less overloading, a larger and, therefore, dearer motor would have to be chosen in order to overcome the variations of load, than in a system which will allow more overloading.

Now, I beg to remark that according to Messrs. Ganz and Co.'s price list, the price of an alternator is about equal to that of a continuous current machine of the firm of Siemens and Halske, both machines yielding 30,000 watts as generators. In order to decide how much larger and how much dearer, therefore, an alternator would have to be chosen for a varying load than a continuous current motor, remember that only about 60 per cent. of the given load may suddenly be thrown on to the alternator without stopping it, whereas we learn that the 1·5 H.P. motor of Messrs. Schuckert and Co. allowed an overloading of ten times its normal load when starting, *i.e.*, 1,000 per cent. of its output as a generator.

Some other remarks I prefer to reserve for a better opportunity. Without doubt the work of the Frankfort committee will interest a large public and it may be of some importance for the development of the art of electrical distribution, that the superiority of the continuous current over the alternating is expressed, if not by a common decison of the experts, at any rate by often repeated passages like the following: "In this respect, therefore, the continuous current is superior to the alternating."

It is certainly remarkable, that of five experts, only Prof. Ferraris expressed himself against the use of accumulators and Mr. Lindley gave no opinion on this question, while three of the experts judge favourably of the use of accumulators on a large scale.

This shows how wide a confidence is bestowed on the Tudor accumulators by competent persons.

Dr. Nordmann.

Berlin, *March 10th*, 1890.

Hydro-Carbons in Arc Lamps.

In reference to an article in the last number of the ELECTRICAL REVIEW, upon the subject of improving the arc light by introducing into it hydro-carbon vapour, I enclose a copy of a specification of a patent taken out in the year 1879, which, perhaps, will be interesting, and point to work upon the subject in the past.

Extensive experiments were carried out during the greater part of the year 1879. Part of the experiments were made at the works of Messrs. Siemens Brothers, at Charlton, and part at Messrs. Sennett Brothers, Holland Street, Blackfriars. To carry out the experiments no expense was spared, and the result may be briefly summed up as follows :—In consequence of the intense heat of the arc, the hydro-carbon vapour was deposited in the form of solid carbon, and the tube in a short time was choked up. If impinged upon the arc from the outside, the carbons were built up in all kinds of fantastic forms, the arc was unsteady, jumping from side to side, and at times becoming extinguished if a little extra vapour or gas was forced in ; the vapour, in fact, increased the resistance enormously. The jumping, apparently, was caused by the current selecting a path where the vapour or gas was least dense. With a given electromotive force the vapour decidedly shortens the arc instead of lengthening it.

Unfortunately, my notes upon the subject have been destroyed ; but perhaps Mr. Alexander Siemens, who took great interest in the matter, may be able to supply some, if the subject is of sufficient importance. I will endeavour to look up some of the carbons, and forward them for your inspection.

Geo. Grout.

March 15th, 1890.

Lightning Conductors.

In the working theory given in my contribution, which appears in your last issue under the above heading, I state in proposition 5, "That matter not only resists being put into bodily motion, but it opposes resistance to internal motion." Regarding as I do all physical phenomena to be connected to one another by a process of continuity, it should have been added that according to the views held by me the inertia matter opposes to the different modes of motion varies, the inertia of matter to bodily motion being the greatest of all, that the inertia opposed to molecular motion is very much less than that opposed to bodily motion, that the inertia to heat motion is still less than that which matter opposes to molecular motion, and that the inertia opposed by matter to atomic which I consider to be synonymous with electrical motion is the least of all.

Now bearing in mind that the source of all motion is energy acting on matter, the heat developed in a conductor according to my theory arises simply from a certain amount of the electric motion passing into heat motion as a consequence of the retardation in its rate of movement brought about by the resistance encountered.

S. Alfred Varley.

March 19th, 1890.

Wynne's Patent Electric System.

My attention has been drawn to the enclosed French newspaper, in which it appears to me that a very similar system was tried in France some time ago. It may interest your readers. Will you be kind enough to return me the paper?

C. H. Wilkinson.

March 17th, 1890.

[The article to which our correspondent refers appears in a kind of double sheet programme or plan guide, No. 1, of June and July, of the Vincennes Exposition of 1887. There seems to be but little in the construction of the line, which was an arrangement of Mr. Holroyd Smith, identical with that devised by Mr. Wynne, and it must not be forgotten that this gentleman was engaged previous to that date in perfecting his ideas.—EDS. ELEC. REV.

Far Distance Dynamo.

In reply to your correspondent's letter of the 10th inst., contained in your issue of the 14th, we do not think he has quite understood the principle of the F.D. dynamo.

The main dynamo is an ordinary compound machine regulating itself according to the number of lamps in circuit. The F.D. dynamo is employed as an auxiliary to produce the required E.M.F. for the loss in the feeders F.F.

The whole of the current generated by the chief compound dynamo at the central station passes round the F.Ms. of the F.D., through its armature, on to the lamp and back through the return lead to the main dynamo.

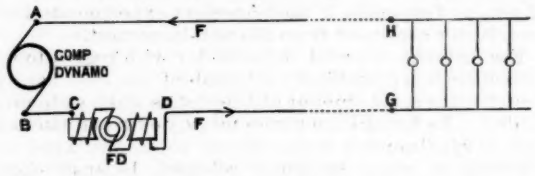
Assuming the speed of the F.D. remains constant, the E.M.F. generated will always be in proportion to the current which is passing through it.

These F.D. machines can be arranged that with a constant number of revolutions and a certain maxim current, to generate a certain maximum E.M.F., *i.e.*, an additional tension to the tension with which the main dynamo is working.

If the maximum E.M.F. of the F.D. at a maximum current of say 200 ampères amount to 20 volts, the E.M.F., or, as we may it the auxiliary tension at 100 ampères will amount to only 10 volts at 50 ampères to 5 volts and so on.

Or if we express the above in other words: The E.M.F. (auxiliary tension) generated by the F.D. is always in proportion to the primary current passing through the feeders.

Now, if the resistance of such a distant line be for instance R ohms, the loss of tension in such a distant



line at a certain potential passing through it will amount to $e = c \times R$.

Assuming the main circuit is to transmit in maximum 200 ampères which will suffer a maximum loss of tension of 20 volts, this main line will have a resistance of $R = \frac{e}{c} = \frac{20}{200} = 0{\cdot}1$ ohm.

Now, if only half the maximum current (200 ampères) = 100 is passing through the same line, the loss of tension will naturally be reduced to half of its former amount = 10 volts instead of 20.

If you then place the above mentioned F.D in this circuit so that its tension is added to that of the chief dynamo at the station, the F.D. will, when running with its proper number of revolutions, naturally add just as much E.M.F. or auxiliary tension as the loss of tension in this line amounts to, and in case the whole number of lamps in the net of the distant line are burning, it will just add 20 volts, and if only half are lighted, the F.D. will add 10 volts according to the reduced current passing around its magnets and through its armature.

Between H and G is required a constant E.M.F. of, say 110 volts.

The compound dynamo will give a constant E.M.F. of 110 volts between A and B.

The loss of potential in the feeders F.F. be *e* volts.

Then the F.D. will always give an auxiliary E.M.F. between C and D, *i.e.*, in addition to the E.M.F. between A and B, so that this auxiliary E.M.F. is always equal to the loss in the feeders.

The above refers only to continuous currents; the F.D. would not regulate an alternating current, though it may be already transformed to the lower tension of 100 or 110 volts.

Bolling and Lowe.

March 18th 1890.

Subdivided Conductors for Electric Traction.

As the interpretation of the patent, No. 783, taken out by Prof. Perry and myself in 1881 (as well as of numerous other patents regarding electric traction in which we are interested) must rest with a tribunal having greater authority than can be exercised by the readers of a technical journal who may glance at its correspondence columns, I do not intend to be drawn into a newspaper controversy.

I may, however, mention that when the late Prof. Fleeming Jenkin took out his first patent, No. 1,830, in 1882, for a system of subdivided conductors for electric traction, in which the length of each section of the rubbed conductor and the distance apart of the contact boxes at its ends were *slightly less* than the length of the moving train, his own patent agent expressed the opinion that such a plan could not be worked without the payment of royalty to Prof. Perry and myself. Prof. Jenkin then entered into a working arrangement by which he transferred to us two-thirds of this and of all his subsequent patents connected with electric traction taken out in Great Britain and other countries, and which numbered some 15 before his untimely death, in return for one-third of our patents on the same subject transferred to him.

W. E. Ayrton.

March 18th, 1890.